POWER

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SHALL MONOPOLY HOLD THE REINS?

Condenser and Cooling Tower for Mixed-Pressure Turbine

By George F. Pond*

SYNOPSIS—The condensing and natural-draft cooling-tower equipment installed at a silk mill forms an efficient unit for installation in connection with a mixed-pressure turbine. The plant is a typical example of what can be done. There are also included some test figures showing the vacuum maintained under adverse atmospheric conditions of temperature and humidity.

Plants built primarily to generate power, as central stations, are located along a water front to obtain ample cooling water for the condensers, but many mills, factories and industrial plants must be constructed where cooling water is scarce or unavailable. For this reason, noncondensing engines have been installed usually and the loss in the steam escaping to the atmosphere has been considered as unavoidable.

The lack of condensing water has also been a drawback to the use of mixed-pressure and low-pressure turbines in such plants, although by their use under suitable conditions the power capacity can be almost doubled for the same coal consumption and boiler-house equipment. The savings attainable are so great that it pays to install apparatus for artificially recooling the condensing water; the only problem is in selecting a recooler which is as nearly equivalent as possible to a natural supply of cold water.

There are many devices for recooling water, including large artificial ponds, spray nozzles, open cooling towers, closed cooling towers of the forced-draft type, and closed cooling towers of the natural-draft type. Inclosed cooling towers are an efficient means of recooling water and the natural-draft tower gives excellent results where the ground area available for it is sufficient.

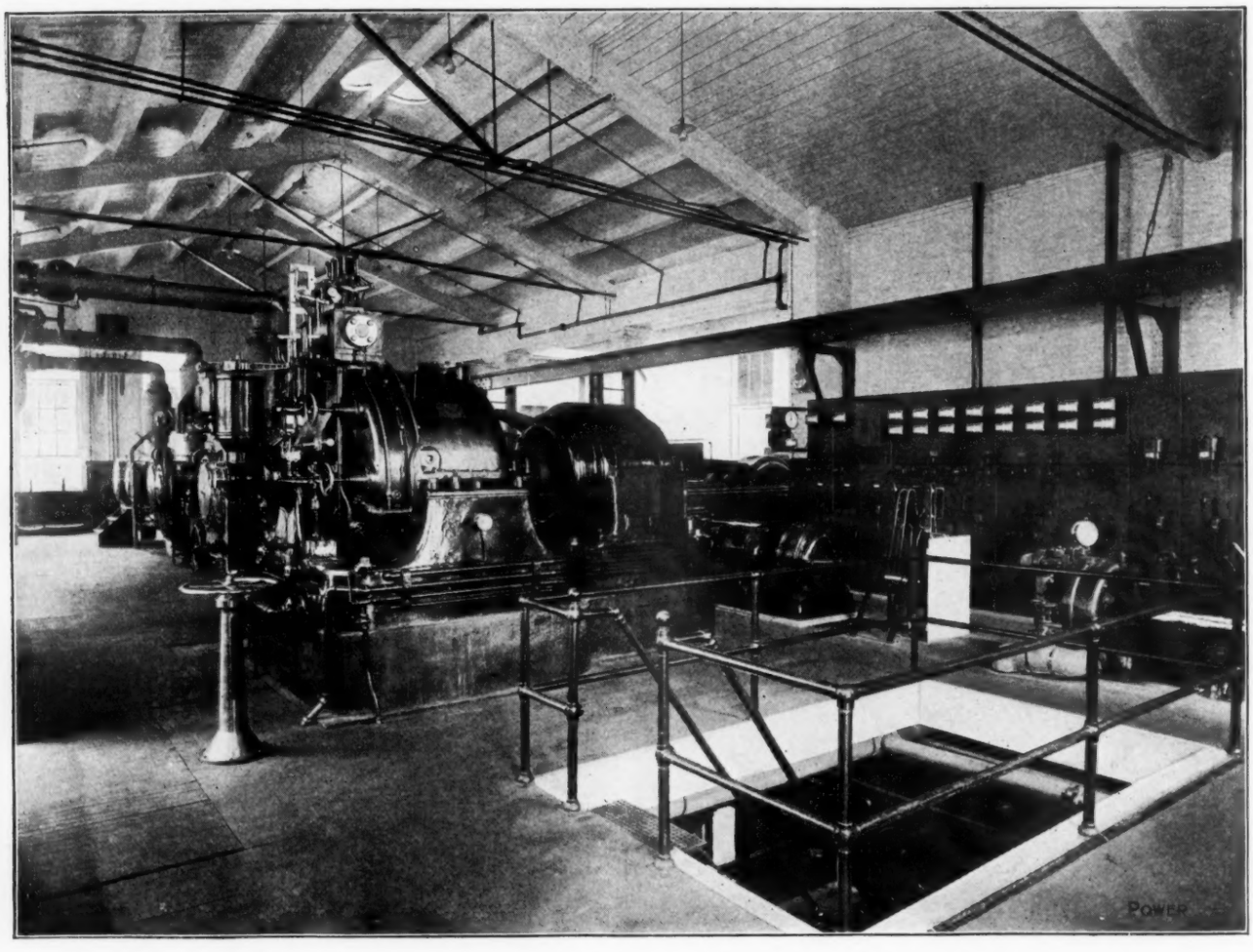

Fig. 1. Turbine and Engine Units in Engine Room of the Sauquoit Silk Mfg. Co.

At the plant of the Sauquoit Silk Mfg. Co., Scranton, Penn., there is a mixed-pressure turbine, condensing plant and a natural-draft, chimney-type inclosed cooling tower.

The steam turbine is a 500-kw. mixed-pressure, 3600-

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r.p.m. unit, driving a 60-cycle alternator and is supplied with exhaust steam from three 300-hp., cross-compound engines, seen behind the turbine, Fig. 1. Any deficiency in the exhaust of the engines is made up automatically by the live steam admitted to a high-pressure stage of the turbine through which it expands before joining the low-pressure steam.

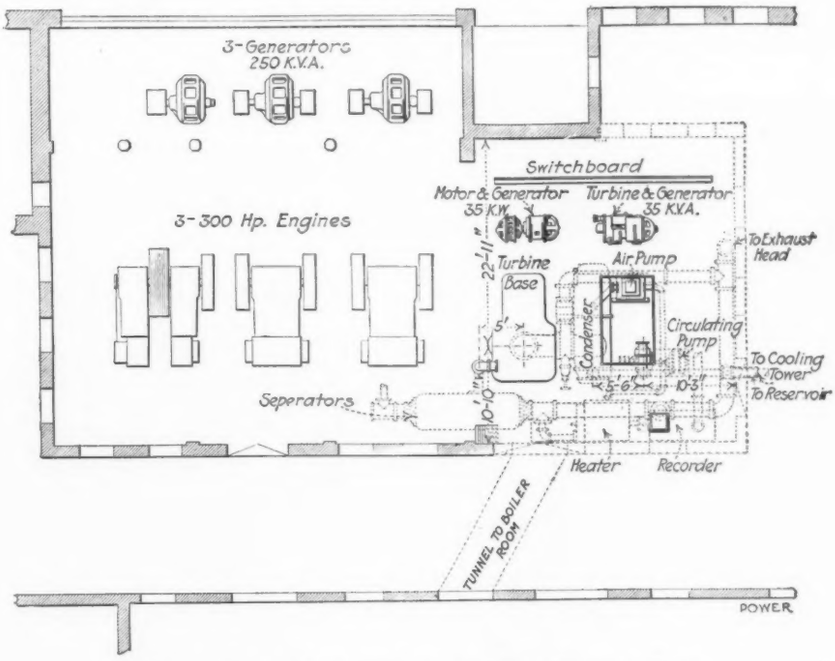


FIG. 2. PLAN VIEW OF OLD AND NEW ENGINE ROOM

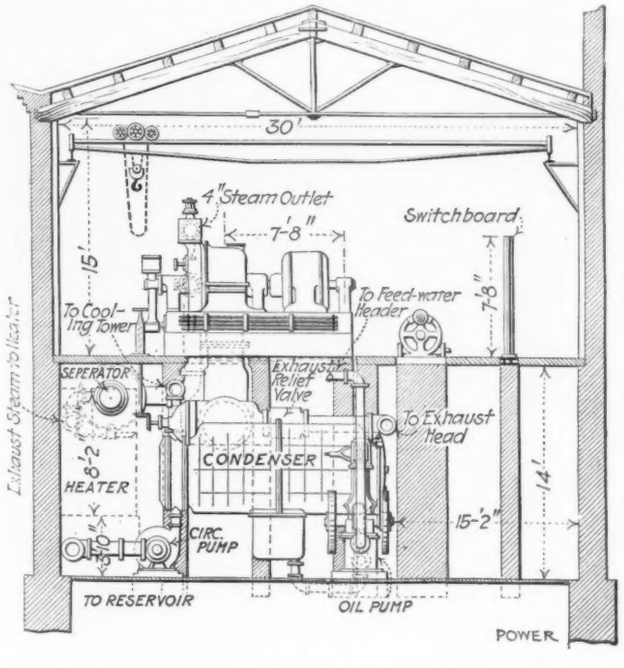


FIG. 3. CROSS-SECTION THROUGH NEW ENGINE ROOM

The condensing equipment comprises a surface condenser, a motor-driven circulating pump, an air pump and a natural-draft cooling tower. The condenser is guaranteed to condense 20,000 lb. of steam per hour and maintain a 27-in. vacuum when the air is at 75 deg. temperature and 70 per cent. humidity. Fig. 2 shows the general arrangement of turbine, condenser and cooling tower.

The atmospheric conditions of 75 deg. of temperature and 70 per cent. of humidity are the average for July and August, the least favorable months in the year, while

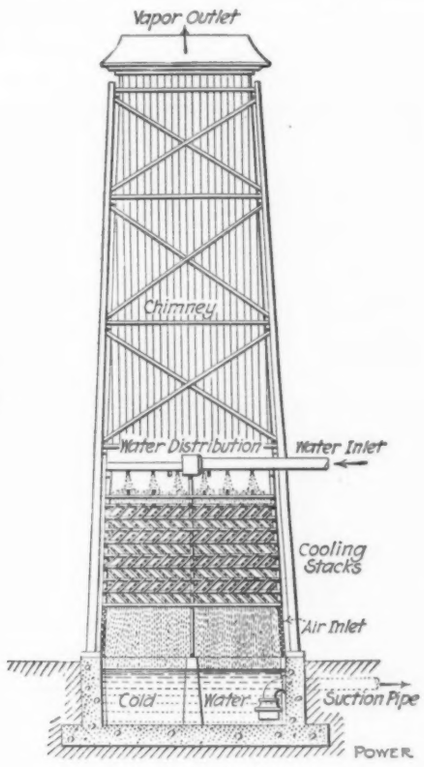


FIG. 4. SECTION THROUGH NATURAL-DRAFT COOLING TOWER

the average annual conditions are about 55 deg. of temperature and 70 per cent. of humidity. The vacuum at the exhaust of the turbines averages 27 in. during the hottest months, and at the other 10 months, between 27 and 28 in., going even slightly above 28 in. at times of low temperature and humidity.

The condenser, Fig. 5, is of the rectangular-shell design. The circulating water makes two passes through it and is heated to within a few degrees of the exhaust-steam temperature, as shown by the test figures given.

The condenser and pumps are in the basement beneath the turbine, the pumps being shown in Figs. 3 and 6, in which the air pump is in the front and the motor-driven circulating pump in the rear. The air pump is of the single, steam-driven type, operating at 95 r.p.m. The air-discharge vent is shown, also the discharge pipe for the condensate, which is delivered to a height of 12 ft. without the aid of a separate pump. The motor-driven circulating pump has a capacity of about 1600 gal. per min., the water being drawn from the sump of the cooling tower, pumped through the tubes of the condenser and delivered to the distributing troughs of the tower at an elevation of about 20 feet.

Fig. 7 is an exterior view of the tower. Its base is square in section and the chimney is octagonal, and has a pleasing appearance. The height of the chimney above the foundations is 70 ft., giving ample natural draft and making fans unnecessary. When once installed, the tower requires no attendance and consumes no power.

Fig. 4 shows the tower in section and illustrates the arrangement of the zigzag cooling stacks and the distributing system; the latter consists of wooden troughs from which the water falls through iron spouts to splash plates, which throw the water out in all directions and distribute it evenly over the whole area of the filling.

The water is cooled in two ways: first, by the evaporation of a small percentage which abstracts approximately 1000 B.t.u. (cooling 40 lb. 25 deg.) for each pound of water evaporated and secondly, by the heat taken up by the warming of the air. This latter is only a small percentage of the cooling, by far the greatest part being due to evaporation.

It is of interest to compare the quantity of water lost and the make-up required due to this evaporation in the tower, with the loss of water by noncondensing engines. If all the cooling is by evaporation, then approximately 1 lb. has to be evaporated to dissipate 1000 B.t.u., which is equal to the heat given up to the water by the condensation of 1 lb. of exhaust steam. Actually, the increase in the temperature of the air absorbs about 20 per cent. of the heat in the tower so that the loss of water is 80 per cent. of the condensation. Without the low-pressure turbine, all of the steam would be exhausted to the atmosphere and only half the power generated or for the same power, twice the steam would be exhausted, representing more than twice the loss of water per kilowatt-hour. Where city water must be purchased at meter rates, this saving in water alone is a considerable item.

The following tables show the results obtained in August, 1913, with loads of 450 and 500 kw. on the turbine running with exhaust steam, corresponding to an engine load of 400 kw. With atmospheric conditions of 74 deg. temperature and 86 per cent. humidity and a load of 450 kilowatts, the vacuum corrected to a 30-in. barometer was 27.55, and at 500 kilowatts and the same atmospheric conditions, the vacuum was 27.4:

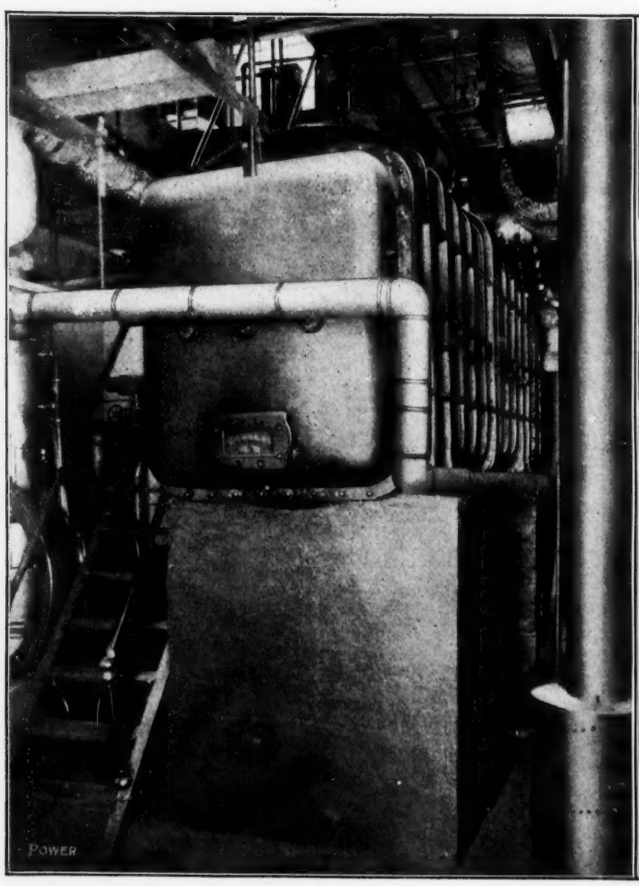


Fig. 5. Condenser and Concrete Foundation

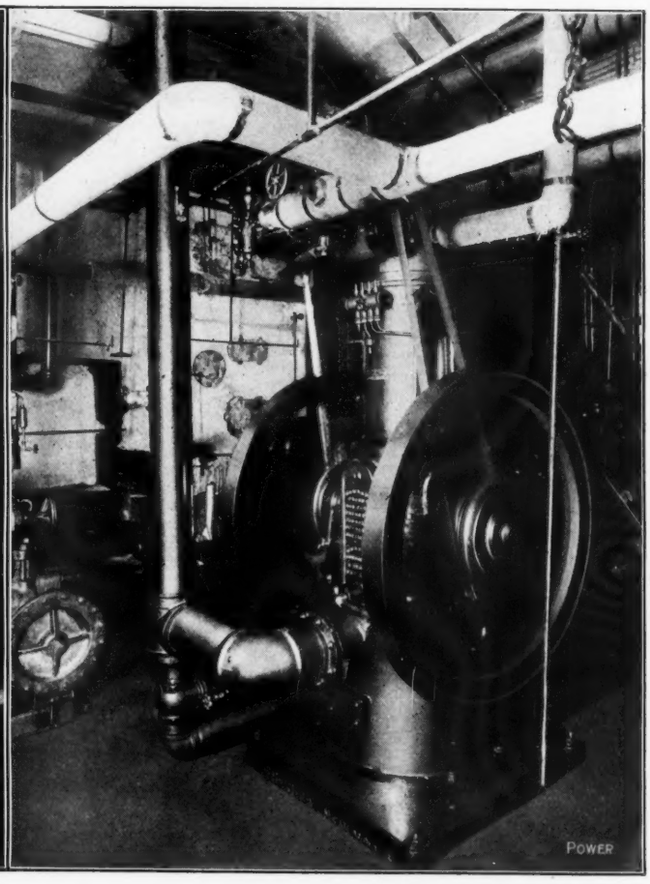


Fig. 6. Air Pump and Piping

TEST NO. 1
Aug. 6, 1913

Turbine load	450 kw.
Temperature exhaust steam entering condenser	108°
Temperature circulating water, in	84°
Temperature circulating water, out	104°
Temperature condensate	90°
Temperature atmosphere	74°
Per cent. humidity	86
Per cent humidity corrected to 30-in. barometer	27.55 in.
Vacuum per cent. humidity corrected to 30-in. barometer	27.55 in.

TEST NO. 2

Load on 500-kw. turbine	500 kw.
Temperature exhaust steam entering condenser	112°
Temperature circulating water, in	86°
Temperature circulating water, out	107°
Temperature condensate	97°
Temperature atmosphere	74°
Per cent. humidity	86
Vacuum corrected to 30-in. barometer	27.4 in.

The atmospheric conditions are considerably less favorable than the guarantee, while the vacuum is almost half an inch higher. This high vacuum is probably explained in part by the margin of capacity of the apparatus; also, because the turbine was not operating on low-pressure steam and the amount of steam condensed at 500 kilowatts was somewhat less than the rated 20,000 lb.

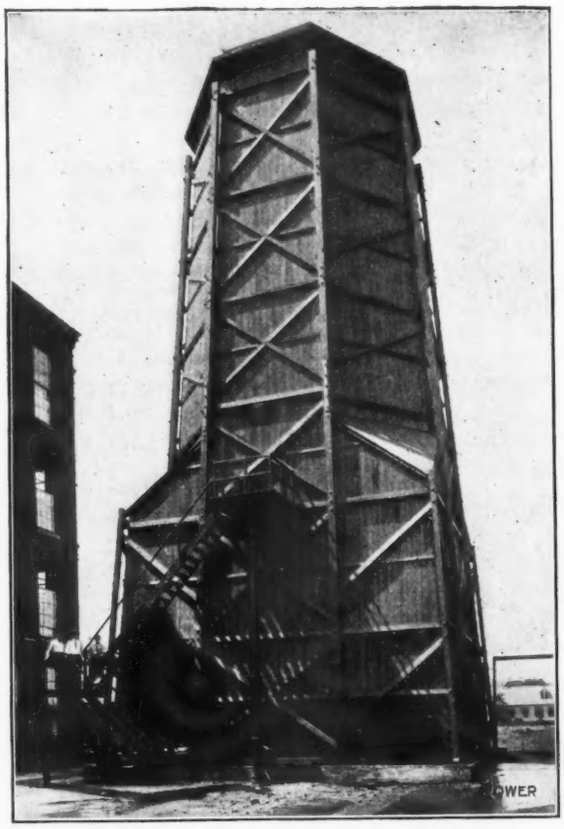


FIG. 7. NATURAL-DRAFT COOLING TOWER

This equipment has been used for about a year. The operating records show that during the winter months the vacuum is about 28 in., and the average vacuum throughout the year is 27½ in. The increase in plant economy due to the installation of the mixed-pressure turbine, the cooling tower and the condensing equipment amounts to a large sum per year; it is estimated that the entire equipment will pay for itself in five years.

The plant was designed and installed by the Sauquoit Silk Mfg. Co., under the direct supervision of their mechanical superintendent, L. G. Schlehner.

A Gas-Pumping Station

BY D. O. BARRETT

About three miles southeast of the city of Mansfield, Ohio, is located one of the gas-pumping stations of the Medine Gas & Fuel Co. An exterior view of the plant is shown in Fig. 1. The large central building houses the main pumping engines, while the auxiliaries are located in the building at the left. The water tank has a capacity of 30,000 gal. All the buildings are of steel construction throughout, with corrugated iron covering.

At present there are two main units, each rated at 475 hp., provision having been made for the installation of a third unit, which will be put in shortly. These engines were built by the C. & G. Cooper Co., and are 21½-in. bore by 36-in. stroke. At the flywheel end is placed the 15x36-in. Hall single-stage compressor supplied with an 8-in. suction and a 6-in. discharge pipe, the compressor cylinder being operated from the crosshead.

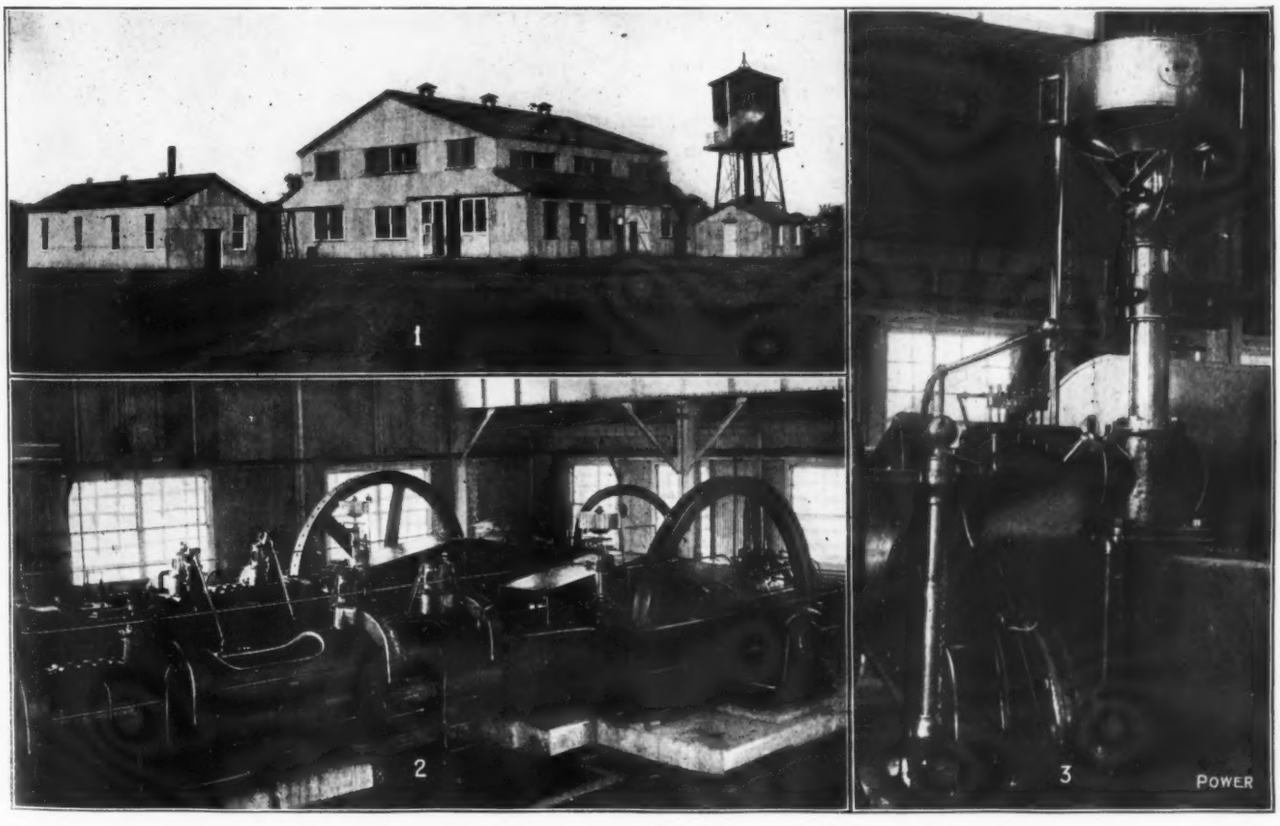


FIG. 1. PUMPING STATION. FIG. 2. GAS-ENGINE PUMPING UNITS. FIG. 3. GOVERNOR SHOWING SPEED-CHANGING DEVICE

Since it is not always convenient nor economical to operate at full speed, due to the frequently occurring light loads, one of the engines was fitted with a speed-changing device, shown in Fig. 3. This is similar to the feed box on a lathe, the lever being provided with five positions, giving speeds of 60, 70, 80, 100 and 125 r.p.m., the latter being the rated speed of the engine. Changes may be made while the engine is running, care being taken to throw the gears in quickly and but one step at a time. The lever projecting from the gear case is arranged with a spring handle and carries a sliding frame in which is located an idler gear. The Richardson oiling system is used, the overflow cup being shown back of the governor.

Just back of the power house is a large pond supplied from an artesian well. In the pond are laid sixteen 4-in. gas lines about 200 ft. long, through which the gas is transmitted before entering the mains. This quite effectively cools the gas. The pipes are attached to headers in such a manner that any pipe may be cut out should it become necessary at any time to make repairs.

The auxiliaries consist of two 30-hp. Superior gas engines connected to a line-shaft from which are driven a two-stage air compressor, two 300-gal. centrifugal pumps and a 6-kw. generator connected to a 20-cell storage-battery plant. A boiler is also provided for steam heating.

The discharge pressure into the gas line varies from 175 to 200 lb., while the suction pressure is extremely variable, depending entirely upon the weather, which regulates the amount of gas being pumped. The engineers work in 12-hr. shifts, each being provided with one helper.

Hand-Fired Settings for Heating Boilers*

By Osborn Monnett†

SYNOPSIS—Description of settings designed for smokeless operation, with full instructions on starting, firing, cleaning and banking.

In previous articles, the discussion on hand-fired furnaces applied particularly to rates of combustion of from 15 to 30 lb. per sq.ft. of grate surface per hour; in other words, to ordinary power loads. The double-arch, bridge wall setting is not so well adapted to rates of combustion lower than this, although the McMillan and twin fire-arch furnaces may be used either for low or for high rates of combustion, owing to the projection of the refractory material forward of the bridge-wall, this having the effect of maintaining a high-temperature zone with a slow fire.

A setting known as the Department No. 7 has been worked out for rates of combustion below 15 lb. per sq.ft. of grate surface per hour. This setting, shown in the accompanying illustration, consists of an arch sprung over the grate, with a deflection arch behind the bridge-wall, the two being connected with a single-span arch over the bridge-wall. The brickwork over the grates has the effect of creating and maintaining a high-temperature zone which would not be possible when the rate of combustion was low unless this refractory material was provided. It also interposes an extended flame travel at high temperature and a good deflection against the arch in the combustion chamber. On the sizes from 66 in. by 18 ft. up, the deflection arch should be built of two spans with a 13-in. pier in the center, as this kind of construction lasts longer and provides better deflection. The illustration and the table give the necessary dimensions for this type of setting for all commercial sizes of horizontal, return-tubular boilers.

DIMENSION SHEET FOR NO. 7 FURNACE
All dimensions in inches, except column B, which is in feet.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
48	14-0	34	20	48	48	24	15	48½	4	16½	54	16	18	20	27	21½	18½	15	8	9	8	4½	6	9
48	16-0	34	20	54	48	24	15	53	4½	15½	56	16	18	22	30	23	20	16½	8	9	8	4½	6	9
54	14-0	36	22	48	54	24	18	48½	4	18½	54	16	18	20	27	21½	18	15	9	9	9	4½	7	9
54	16-0	36	22	54	54	24	18	53	4½	17½	57	17	18	22	30	23	19½	16½	9	9	9	4½	7	9
60	16-0	40	22	60	60	26	18	63	5	15½	64½	18	22½	24	33½	29½	25½	18½	10	9	10	9	7½	9
60	18-0	40	22	66	60	26	18	66½	5½	14½	66½	18	22½	26	35½	31	27	20	10	9	10	9	7½	9
66	16-0	40	24	60	66	28	19	64	5	15	64½	18	22½	24	34	30	25	19	11	9	11	9	8½	9
66	18-0	40	24	66	66	28	18	68½	5½	14	68½	20	22½	26	37	31½	26½	20½	11	9	11	9	8½	9
72	16-0	42	24	66	72	30	20	73	5½	16	74½	22	22½	30	41½	31½	27	20½	4	9	12	9	9	9*
72	18-0	42	24	72	72	30	20	79	6	14½	78½	24	22½	32	46	33	28½	22	4	9	12	9	9	9*

Note—First grade of firebrick to be used throughout with the exception of the combustion-chamber floor and the side walls of the chamber back from a point 1 ft. behind the rear face of the deflection arch.
Fire doors must provide for special air admission of an area equal to 4 sq.in. for each square foot of grate surface.
Make damper openings equal to 25% excess of tube area.
Dimensions in the above table apply only for the ordinary conditions, and are subject to revision for unusual conditions.
*Deflection arch built with a 13½x13½-in. center pier.

Firing a No. 7 Setting

The methods of starting, cleaning and banking the fire are the same as given in the last article for power boilers. In operation, however, the coking method should be used. This consists of heavily charging the front part of the furnace with coal, allowing it to ignite and coke, pushing back the coked portion to expose the fresh coal near the dead plate, and finally pushing back the entire fuel bed and refilling the front part of the furnace with fresh coal. This should be done by the alternate method, using the panel doors freely. As the boiler operates at low pressure there will be no steam jets available, so that smoke suppression must be accomplished entirely by the use of the panel doors. When the coking method is used there need not be much trouble from smoke, as the rate of combustion is such that the volatile does not necessarily have to pass off at a high rate.

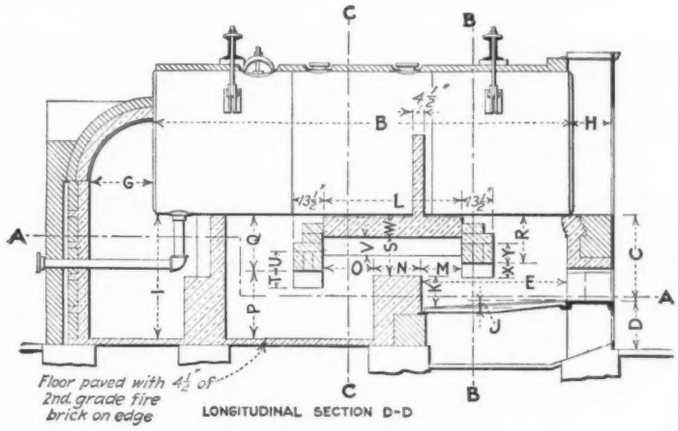
In using the alternate system with the coking method

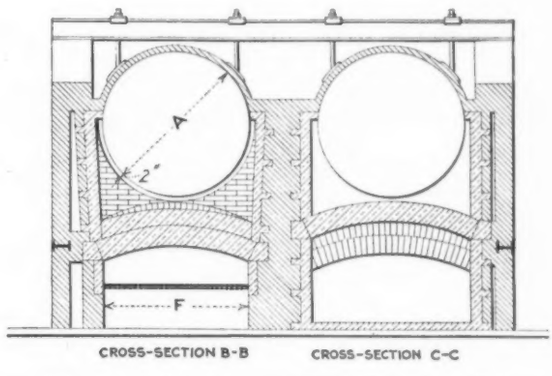
*Copyright, 1914, Osborn Monnett.
†Smoke inspector, city of Chicago.

of firing, push back one side at a time and fill up with green coal. The next time this side is stoked, the coal on top near the door which is partially coked is pushed back, leaving the unburned green coal underneath to coke on the grate. When this has been coked it is pushed back, the front part of the furnace refilled, and the same operation is repeated.

Firebox Boilers

The locomotive firebox has come into general use for heating purposes in buildings where the return-tubular boiler would be too large. Thousands of these boilers are used in flats and residences, only one boiler being installed at each place. It is necessary to use extreme care in firing this type with any kind of coal if smokeless results are to be obtained. In fact, it is practically impossible to use a coal with the volatile content higher than 20 per cent. and expect satisfactory smoke conditions. For this reason, this type is limited to the use of semi-bituminous coal. With intelligent care, this coal can be fired in a firebox boiler without making dense smoke. The following instructions apply specifically to this kind of boiler and should be followed carefully if smoke suppression is an important consideration.





Return-Tubular Setting for Low Rates of Combustion

Starting a New Fire—Have the ashpits, grates, tubes and all other accessible parts clean. When starting a fire, always have a large amount of kindling ready for use. This is necessary because the heat from the wood fire must ignite the coal and maintain heat long enough to give the coal a good start.

Open the ashpit doors. This does not mean the panels. Make sure that the damper in the smoke connection is wide open. Put into the firebox, on the bare grates, a layer of coal about 6 in. thick immediately inside of the fire-doors and gradually thinning down to 1 in. at the tube sheet. Place the kindling wood on top of the coal. Sprinkle one scoop of coal over the wood. Light the wood at the front, close the firing doors to within ½ in. of being tight and leave the circular shutters in the doors wide open. The coal will burn from the top down, being ignited from the wood. Any good coal that drops through the grate can be scraped out of the ashpit and used when the fire is under way.

Regular Firing—Push the live coal from the top of the fuel bed at the front of the grates back toward the tubes. Do not push any green coal back, as this will cause smoke. Put a heavy charge of fresh coal on the front of the grates immediately inside the doors. Do not close the fire-doors tight; have them stand open about ½ in. Repeat this operation for each successive firing.

The live coal on the back half of the grates will maintain the required heat and cause the green coal on the front half to give up its gas. This gas will pass over the live coal and be burned before it reaches the tubes. Run the fire so that the fuel bed is always thick, especially just inside the doors. Do not spread the coal over the entire grate as this will cause a great deal of smoke no matter what kind of coal is used.

Cleaning Fires—The time when it is necessary to clean fires will be indicated by the fact that the boiler cannot make steam fast enough to deliver the required heat. Prepare for cleaning by arranging to have a large charge of coked fuel on the grates immediately inside the doors.

Allow the fire on the back half of the grates to burn down slightly. When ready to remove the clinker, close the ashpit doors and the panels in the doors. Pull the clinker from the back half of the grates over the fire in front with as little disturbance as possible of the fuel bed in front. After the clinker is out, shake the grates. Open the ashpit doors, push the live coal from the front so as to cover the rear half of the grates. Put in a large charge of fresh coal immediately inside the firing doors, leaving them open about half an inch and the circular shutters in the doors full open.

Clinker need seldom be removed from the front half of the grates as it does not form there, and the shaking grates will more than likely take care of the ashes. When it is necessary to remove clinker that has found its way to the front half of the grates, wait at least one hour after having cleaned the back half; then push the live coal lying on the front half of the grate on to the back half and pull the clinker out of the front doors. Fire a heavy charge of fresh fuel just inside the fire-doors,

leaving the doors cracked as before. Do not close the ashpit doors when cleaning the front portion of the grates.

Banking Fires—Push the live coal from the front on to the back half of the grates. Put a charge of fresh coal on the front of the grates immediately inside of the fire-doors, using considerably more coal than for an ordinary firing. This may mean from 15 to 18 large scoops of coal, depending upon the size of the grate. Leave the damper in the chimney connection wide open. Leave the circular shutters in the fire-doors wide open and close the doors themselves.

Starting Up after a Banked Fire—Shake the grates well; there will be little clinker. Open the ashpit door wide. Break the fire down with a bar and then let it burn for 10, 15 or perhaps 20 min., depending upon the quantity of fuel there is in the firebox. When the regular firing begins, put a large charge of fuel on the front half of the grates immediately inside of the firing-doors after pushing most of the live coal back to the back half of the grates. Do not close the stack damper for any cause. Do not allow the tubes to become dirty. Cleanliness is of great importance in a boiler of this type. Do not fail to clean out the smoke connection between the boiler and the chimney, especially at the beginning of the heating season. Do not leave the clean-out door at the bottom of the chimney open. Do not make openings in the chimney for ventilating purposes. Do not depend on the damper regulator.

Graphic Air-Compressor Calculations

By F. H. Rosencrants

SYNOPSIS—Charts for determining horsepower required to compress a given quantity of air and the volumetric efficiency of air compressors, with examples in each case to illustrate their use.

In connection with compressed-air work a common problem is the determination of the power necessary to compress a given volume of air from one pressure (usually that of the atmosphere) to some other higher pressure. It can be shown mathematically that the power absorbed in the cylinder by the air is:

$$hp. = \frac{144\ P_1 V_1}{33{,}000} \times \frac{n}{n-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

in which

P_1 = Absolute suction pressure in lb. per sq.in.;
P_2 = Absolute discharge pressure in lb. per sq.in.;
V_1 = Volume of free air compressed per min. in cu.ft.;

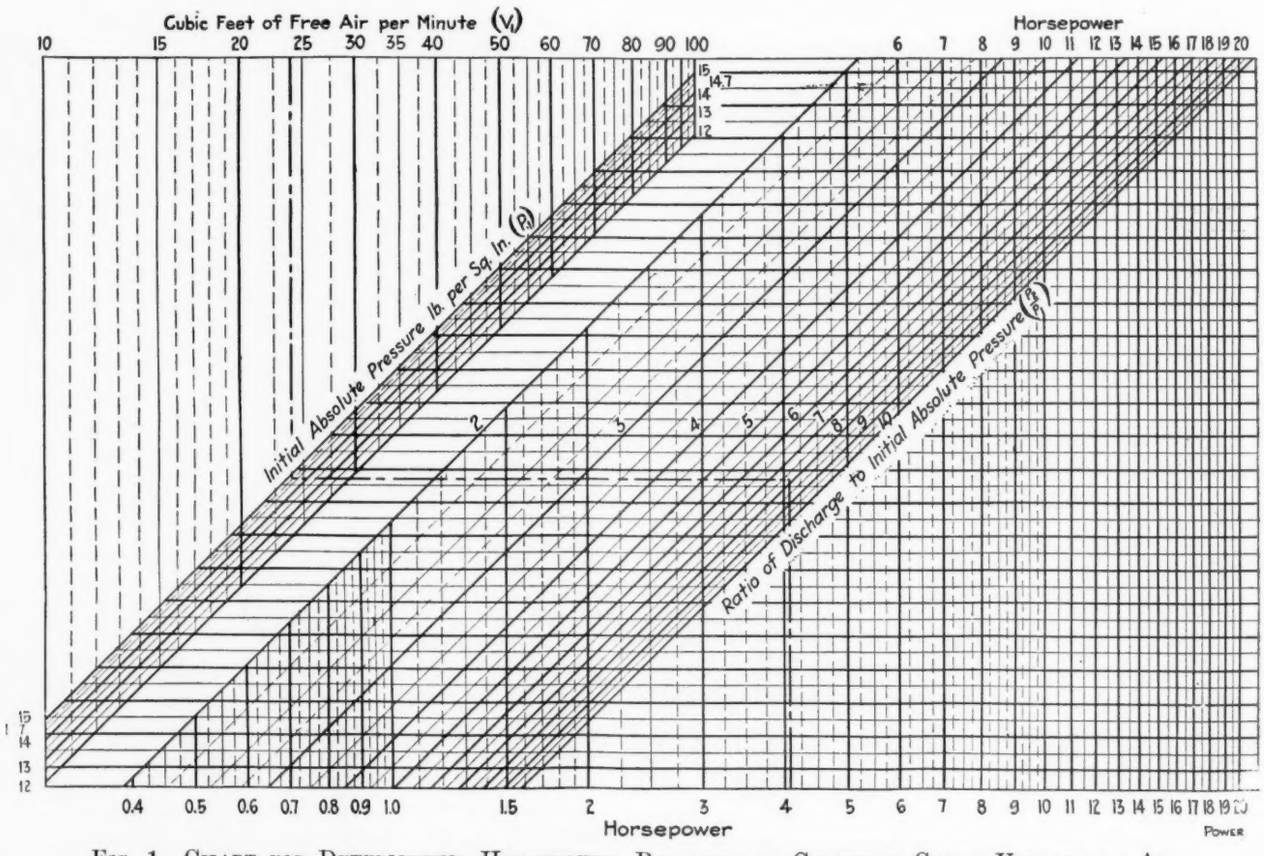

Cubic Feet of Free Air per Minute (V_1)
10 15 20 25 30 35 40 50 60 70 80 90 100
Horsepower
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
15 14.7 14 13 12
Initial Absolute Pressure lb. per Sq. In. (P_1)
2 3 4 5 6 7 8 9 10
Ratio of Discharge to Initial Absolute Pressure ($\frac{P_2}{P_1}$)
0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.5 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Horsepower
Power

Fig. 1. Chart for Determining Horsepower Required to Compress Given Volume of Air from One Pressure to Higher Pressure

n = Factor varying in air compressors from 1.25 to 1.35, depending on the efficiency of cooling by the jacket. A common value of this factor is 1.30.

This formula is long and tedious to apply, especially if one is not familiar with the use of logarithms and calculating devices. It is for the purpose of solving this formula graphically that Fig. 1 was designed. The heavy broken line indicates how the chart is to be used but possibly a brief explanation will make it clearer. The data for the problem solved is as follows:

Volume to be compressed per minute (V_1) = 24 cu.ft.; initial absolute pressure (P_1) = 14.7 lb.; discharge absolute pressure (P_2) = 114.7 lb.

Solution: Starting with the volume of 24 cu.ft. at the top of the chart drop vertically down to the diagonal line representing the suction pressure of 14.7 lb. From there follow to the right to a point between the two diagonal lines labeled 7 and 8 respectively, or to be exact to a point representing 7.8, the value of the ratio

$$P_2 \div P_1 = 114.7 \div 14.7 = 7.8$$

Then drop vertically down to the answer of 4.1 hp. at the bottom of the chart. If a mechanical efficiency of 85 per cent. is assumed the indicated horsepower of the driving engine is

$$4.1 \div 0.85 = 4.82$$

It will be evident that a problem with the same data as above, except that V_1 be 240 cu.ft. per min., would be solved by using the same line and that the answer would be 41 hp., the difference in the solution being in the placing of the decimal point. The range in volume of air on the chart being from 10 to 100 cu.ft. per min. makes the range unlimited by merely shifting the decimal point on the volume scale and making the corresponding change on the horsepower scale.

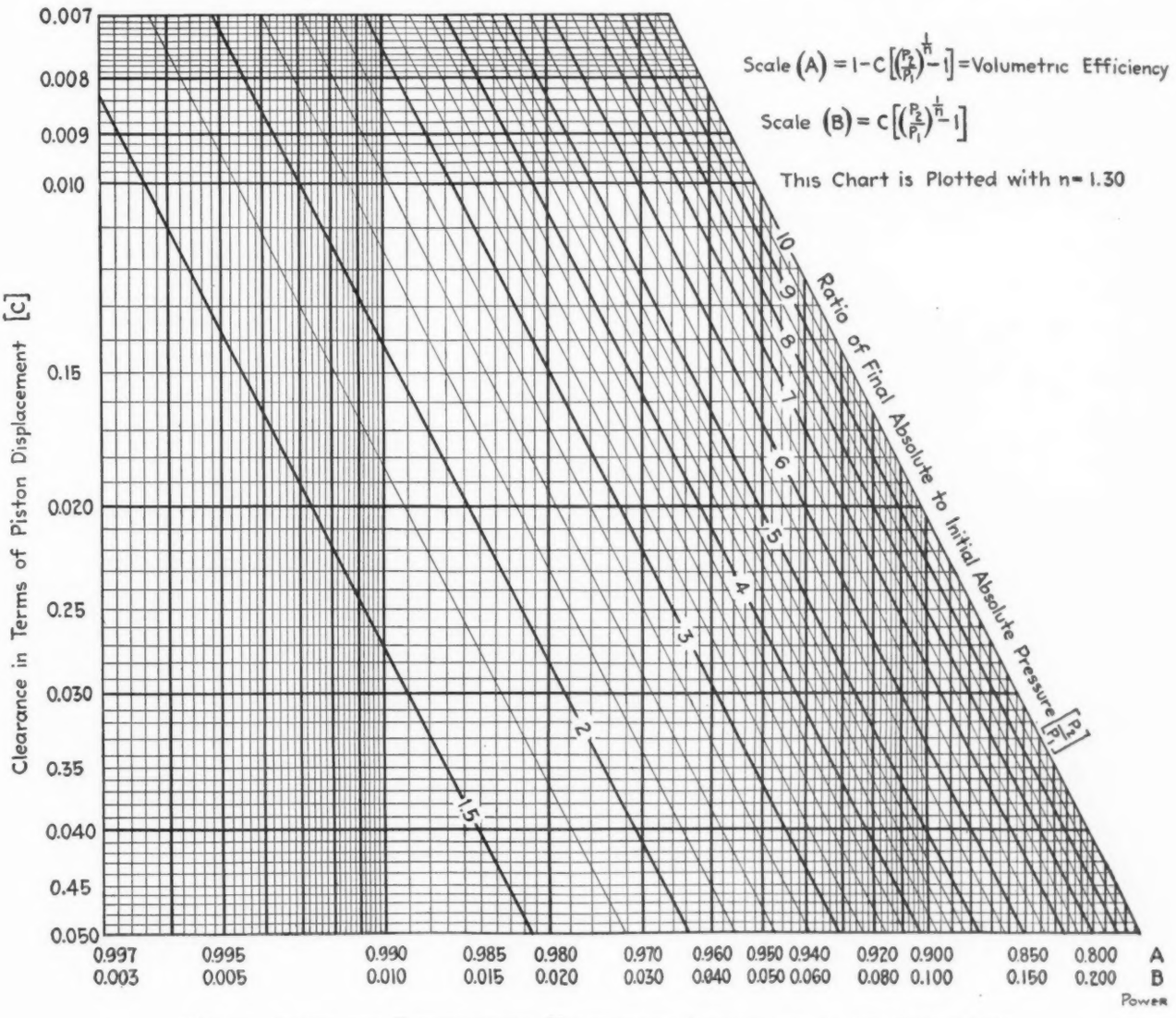


FIG. 2. CHART FOR DETERMINING VOLUMETRIC EFFICIENCY OF AIR COMPRESSOR

The value of the factor n for which the chart was plotted is 1.30. This figure was chosen because it is the value most commonly used. In Table 1 are given factors

TABLE 1. FACTORS BY WHICH TO MULTIPLY RESULTS WHEN n HAS VALUE OTHER THAN 1.3

	Values of $P_2 \div P_1$								
n	2	3	4	5	6	7	8	9	10
1.20	0.976	0.962	0.953	0.946	0.941	0.936	0.932	0.927	0.927
1.25	0.988	0.982	0.977	0.974	0.971	0.969	0.966	0.963	0.962
1.35	1.008	1.017	1.020	1.024	1.028	1.031	1.033	1.036	1.038
1.40	1.016	1.029	1.039	1.048	1.055	1.059	1.063	1.067	1.071

by which to multiply the results when n has a value other than 1.30. To illustrate its use assume that n in the above problem has a value of 1.40, the value for adiabatic

compression of air. The proper factor by which to multiply will be found in the bottom line of the table 0.8 of the way between 1.059 and 1.063, which is equal to 1.062. Therefore, multiplying the chart answer of 4.1 hp. by 1.062 gives 4.35 hp., the desired result.

The use of the chart is not necessarily limited to air problems, since by using the proper value of n it is applicable to any gas. In general the value of n is slightly less than the ratio of the specific heat at constant pressure to that at constant volume of the gas in question.

While the chart is primarily designed to solve problems for single-stage compression, it may be used also to determine the necessary power for two-stage compression. It can be shown that for the most economical results in two-stage compression the intermediate pressure should be equal to the square root of the product of the suction and discharge pressures; i.e., equal to $\sqrt{P_1 P_2}$. It may also be shown that for this intermediate pressure the work done in each of the two cylinders is exactly the same. Therefore, having determined the intermediate

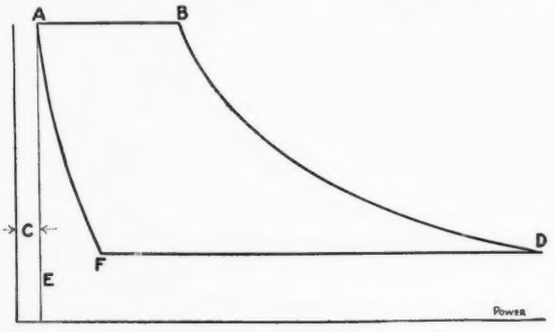


FIG. 3. INDICATOR DIAGRAM FROM AIR COMPRESSOR

pressure, which will be called P', the horsepower absorbed in each of the two cylinders is:

$$hp. = \frac{144\ P_1\ V_1}{33{,}000} \times \frac{n}{n-1}\left[\left(\frac{P'}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

the same formula which the chart was designed to solve. Therefore, having obtained the result of this solution from the chart the total horsepower absorbed in both cylinders is obtained by multiplying by two. To illustrate, assume the same data as for the above problem except that the compression is to be two stage.

Solution: The intermediate pressure is

$$P' = \sqrt{P_2 P_1} = \sqrt{114.7 \times 14.7} = 41.06\ lb.$$

Then the ratio of compression $P' \div P_1$ in the low-pressure cylinder is

$$41.06 \div 14.7 = 2.79$$

For 24 cu.ft. of air per min. and this ratio of compression, the chart gives a value of 1.80 hp. Therefore, the total horsepower absorbed in both cylinders is

$$2 \times 1.80 = 3.60$$

Assuming a mechanical efficiency of 85 per cent., the indicated horsepower of the driving engine is

$$3.60 \div 0.85 = 4.23$$

Fig. 2 becomes useful when it is desired to determine the necessary piston displacement of a compressor to deliver a definite volume of free air under given conditions of suction and discharge pressure. Also in calculating the probable amount of air that a compressor of given dimensions will deliver under given conditions of suction and discharge pressure and speed.

Referring to Fig. 3, representing the indicator diagram of an air compressor, it is evident that when the piston reaches the end of the discharge, or compression stroke, corresponding to the point A, that the clearance volume C will be full of air at discharge pressure. This air will expand as the piston starts back on the suction stroke and no air will be drawn into the cylinder until the pressure therein has fallen to the suction pressure. Hence the volume of air drawn in each stroke will be somewhat less than the piston displacement, the amount being dependent upon the clearance volume and the ratio of the discharge to the suction pressure. The ratio of the air drawn into the cylinder per stroke to the volume of the piston displacement is called the volumetric efficiency of the compressor. In Fig. 3 this ratio is approximately $DF \div DE$. Mathematically expressed the volumetric efficiency is:

$$1 - C\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right]$$

in which C is the clearance volume in terms of the piston displacement and the rest of the notation has the same meaning as in the previous formula.

Fig. 2 is for the purpose of solving this formula. The method of using it is self-evident, but to make it perfectly clear the following example will be solved.

Given: Clearance volume $C = 0.02$ of piston displacement; $P_1 = 14.7$ lb. abs.; $P_2 = 75$ lb. abs.

Required: The volumetric efficiency.

Solution: Starting on the left-hand side of the diagram at 0.020 go in a horizontal direction to a point between the two diagonal lines labeled 5 and 6 respectively, or to be exact to a point representing the value of

$$P_2 \div P_1 = 75 \div 14.7 = 5.1$$

From there drop vertically down to the answer on scale A, which for this case is 0.950.

To make the diagram applicable to problems in which n has a value other than 1.30 the scale B has been placed on the diagram. This is equal to 1 — scale A, or to

$$C\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right]$$

To solve problems similar to the above when n has a value other than 1.30 proceed in exactly the same manner except that the result is read on scale B. Then multi-

TABLE 2. FACTORS BY WHICH TO MULTIPLY SCALE B IN FIG. 2 WHEN n HAS A VALUE OTHER THAN 1.30

	Values of the Ratio $P_2 \div P_1$									
n	1.5	2	3	4	5	6	7	8	9	10
1.20	1.097	1.112	1.132	1.150	1.162	1.169	1.178	1.187	1.192	1.196
1.25	1.041	1.064	1.070	1.077	1.080	1.082	1.088	1.091	1.093	1.095
1.35	0.959	0.950	0.941	0.936	0.932	0.929	0.927	0.926	0.924	0.922
1.40	0.918	0.907	0.892	0.886	0.880	0.872	0.866	0.864	0.860	0.857

ply this by the proper factor from Table 2 and subtract the result from 1, giving the desired volumetric efficiency.

As a last example involving the use of both charts, take the following problem: A single-stage compressor is desired which will compress 2000 cu.ft. of free air per min. from a pressure of 14.7 lb. abs. to a pressure of 70 lb. abs. What should be the piston displacement per minute, and what should be the indicated horsepower of the engine, assuming a mechanical efficiency of 85 per cent.

Solution: From Fig. 1 the power absorbed in the cylinder by the air is 238 hp. Then

$$238 \div 0.85 = 280$$

as the indicated horsepower of the driving engine.

From Fig. 2 the volumetric efficiency is found to be

(assuming a clearance of 2 per cent.) 0.954. Dividing 2000 by 0.954 gives 2096 cu.ft.

To allow for leakage past the piston back through the discharge valves, for effect of rise in temperature during the suction stroke, etc., this quantity should be increased by from 3 to 8 per cent. Therefore, assuming the loss due to these causes to be 5 per cent., the required piston displacement becomes

$$1.05 \times 2096 = 2200.8 \textit{ cu.ft. per min.}$$

Largest Diesel Engine Built in America

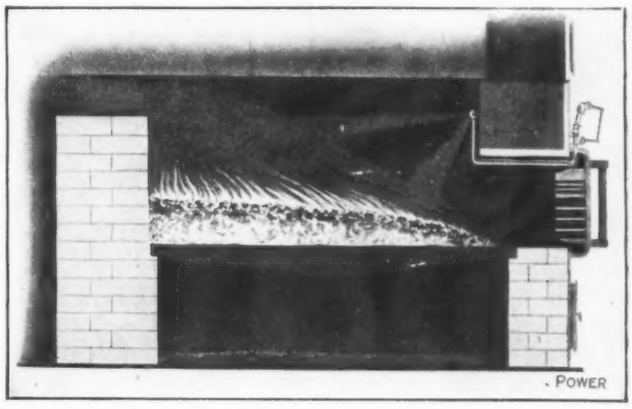
The accompanying photograph shows the largest Diesel engine constructed to date in this country. It was built by the Lyons Atlas Co., of Indianapolis, for the Hawaiian Commercial & Sugar Co., to supersede one of their steam plants for irrigation purposes. It has four cylinders, 21x30 in., is rated normally at 600 hp., or 690 hp. maximum, and will drive a two-stage turbine pump of 15,000,000 gal. capacity at 200-ft. head.

The conditions covering the acceptance of the engine were severe. The purchaser insisted that the engine should operate continuously 710 hr. out of each 720 hr. per month at rated load, using the ordinary 14° to 18° asphaltum base California fuel oil, similar to that used in the purchaser's steam plant, and which is the only grade available on the Islands.

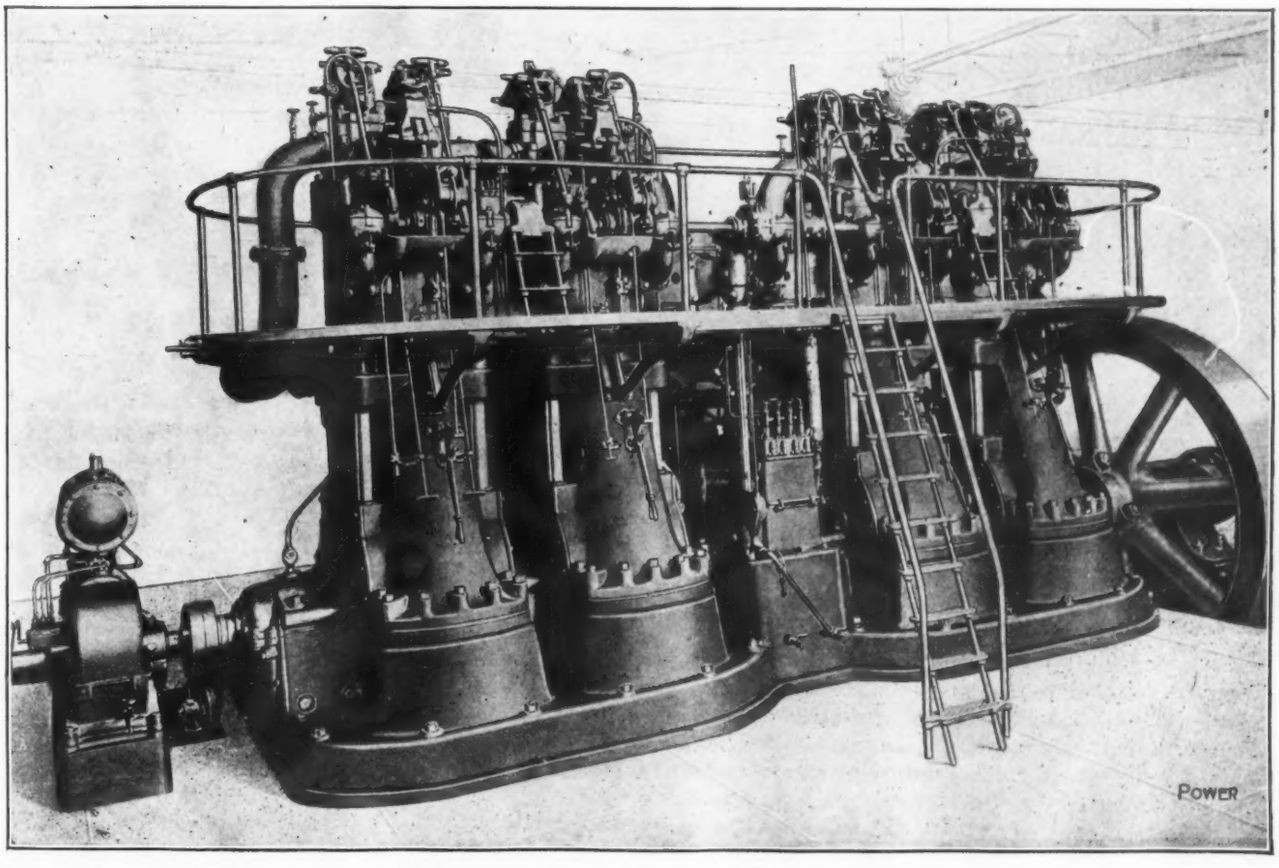
The test was conducted by the chief engineer of the Hawaiian Commercial & Sugar Co., and the engine was given a preliminary, continuous run of 48 hours with Eastern paraffin-base fuel, after which all parts connected with the combustion chambers were inspected in order to determine a basis for comparison between the effect of the two fuels. It was then subjected to a 144-hr. continuous run at full load with fuel shipped by the purchaser from California to the manufacturer's works. At the completion of this run the combustion chambers were again examined, and as no evidence of deposits on the heads, valves or pistons were found, the engine was accepted and is now *en route* to the Islands.

Morse Smoke Consumer

The most active cause of smoke when using soft coal in boiler furnaces is the rapid distillation of volatile from the new coal when first thrown on the incandescent or nearly incandescent fuel bed. During this time of rapid



THE MORSE SMOKE CONSUMER



600-HORSEPOWER, LYONS-ATLAS DIESEL ENGINE

distillation the supply of air or oxygen should be greater than normal, and, if hot, will produce better results, because there is quite a drop in furnace temperature when a hot bed is covered with new and cold fuel and cold air from the room rushes in through the fire door.

The smoke consumer marketed by the R. F. Morse Co., Providence, R. I., has been designed to automatically furnish the increased oxygen at a temperature much higher than that of the room air, and also to retard the flow of gases from the fuel bed sufficiently to allow them to burn before reaching the flue and stack.

These effects are produced by two steam jets, both being projected from a nozzle at the front of the furnace, one so that it is over the fuel bed, the other being projected at a sharp angle, so that it forms a curtain on the inside of the furnace at the fire-door opening. The latter curtain tends to reduce the amount of cold air admitted into the furnace through the fire door, and also furnishes air or oxygen at a temperature above that of the room. Besides furnishing heated air or oxygen, the top curtain tends to retard the flow of gases from the furnace. When the fire door is open, preparatory to charging the furnace, both jets are automatically turned on, and, when closed, the jets are slowly shut off. The back of the fire door is provided with a heater for warming the air admitted to the furnace at this point. The device may be attached to any horizontal boiler furnace without dismantling the furnace or shutting down the boiler.

Applications and Types of Boosters

By John A. Randolph

SYNOPSIS—The classification and uses of automatic and non-automatic boosters, and descriptions of the shunt, series, compound and differential types.

The function of the booster, as implied in its name, is to raise or boost the voltage of electrical circuits. The machine is simply a direct-current generator with the armature and field windings so arranged as to adapt it to the particular service for which it is used. On many systems conditions exist such that it is necessary at times to raise the voltage on certain circuits, either to compensate for line drop or to overcome an opposing pressure, as in charging or discharging a storage battery. The booster is used for both of these purposes, but its most extensive application is in connection with storage-battery installations, wherein it renders possible a broad range of flexibility.

The various types of boosters can, in general, be classified under two headings, namely, the automatic or reversible class and the nonautomatic or irreversible class. The automatic machines are those which charge or reverse their action, without external assistance, from adding their voltage to the station pressure for battery charging, to opposing the station voltage and assisting the battery to discharge. In the nonautomatic group belong those which cannot be reversed at all and those which require the throwing over of a reversing switch before they will change their polarity. In the latter class can be grouped the shunt, series and compound machines, while the automatic class includes the differential and exciter-controlled types.

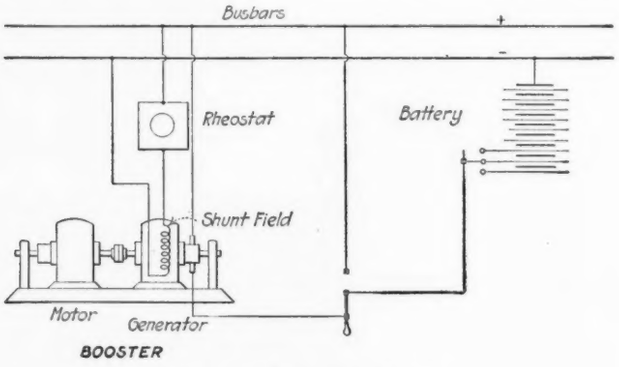


Fig. 1. Shunt Booster

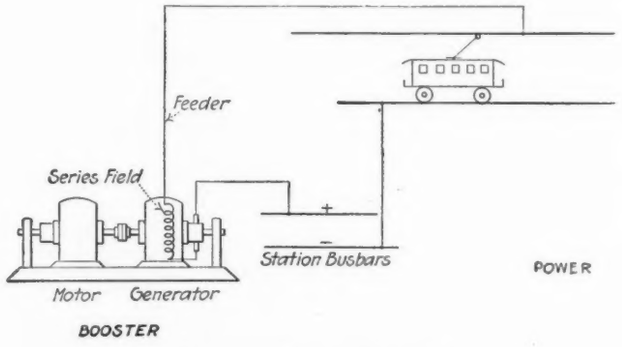


Fig. 2. Series Booster

Shunt Type

This form has one field coil connected either across the station busbars, the battery or the booster itself. As is usual with shunt-wound machines, a rheostat is placed in the field circuit for regulating the excitation. Fig. 1 shows a diagram of connections commonly used for machines of this type. In charging, the single-pole, double-throw switch is thrown downward, and the charging current may be regulated to any desired value by the booster field rheostat. By placing a reversing switch in the booster field circuit, the polarity can be reversed, enabling the machine to assist the battery on discharge when its voltage has fallen to a value nearly equal to or below that of the station busbars. By the use of end cells the battery can be discharged without assistance from the booster. No end cells are necessary, however if the booster is used during discharge. Where the machine is used for both charging and discharging it must be run continuously during both periods. If the booster is to be used on discharge, it must be of a larger construction than otherwise, because of the much heavier current passing on discharge than on charge.

The shunt booster is hand-operated and nonautomatic, hence it must be constantly watched in order to provide the adjustments necessary to compensate for the gradually rising or falling battery voltage.

Series Type

This machine, like the shunt type, has but one field coil, which is in series with the armature, as shown in Fig. 2. In the case illustrated, the machine is used in connection with a long railway feeder. At distant points on such feeders the voltage, unless raised by some means at the station end, is lower than that of the busbars, especially during heavy loads, on account of the loss of pressure due to line drop. This difficulty could be obviated by the installation of a larger copper cross-section, but in many cases it is more economical to use a booster. Where a series machine is used, the full current of the feeder passes through the field coil of the booster, and as the load on the feeder, and the consequent line drop, increases, the voltage of the booster will rise proportionately, thus compensating for the line drop and maintaining a constant pressure at the distant points on the feeder.

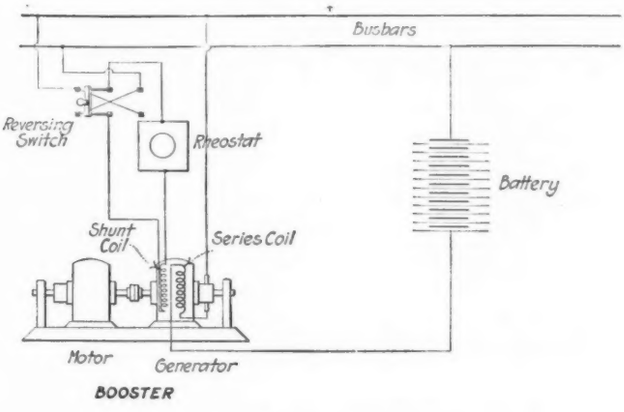


Fig. 3. Compound Booster

Compound Type

The connections for this type are shown in Fig. 3. The field winding is made up of two sets of coils, one in series with the armature and load and the other shunted across the station busbars. By virtue of its two sets of windings, this machine can be made to act automatically under certain conditions. It is generally classed as a nonautomatic machine, however, since there are times when it is necessary to throw over the shunt field reversing switch to secure the proper polarity. When the machine is acting automatically, the battery can float on the line. Under such a condition, the shunt coil is made to produce a pressure in the booster, tending to assist the battery to discharge. The series coil is wound in such a direction that it assists the action of the shunt coil on discharge and opposes it on charge.

Inasmuch as the tendency of both windings is to cause the booster to assist the battery on discharge, the battery will at once take part of the station load whenever the demand becomes so great as to reduce the busbar voltage below the value of the battery pressure plus that of the booster. Now the voltage at the booster terminals, as induced by the series coil, will vary with the strength of the current flowing through the latter. Consequently, as the load on the battery increases, the booster voltage will rise accordingly, helping the battery to meet its demand and thereby maintain the voltage on the busbars. As the station load falls off, the busbar voltage will gradually rise until it becomes equal to the combined pressures of the battery and the booster, thus counterbalancing the latter. During this state of equilibrium no current will flow either way through the battery. However, as the station load is still further reduced, the busbar voltage will rise higher, with the result that the equilibrium between the battery and the busbars is overcome and a charging current begins to flow into the battery. The series winding will now oppose the shunt and tend to remove the opposition of the booster pressure to the charging current.

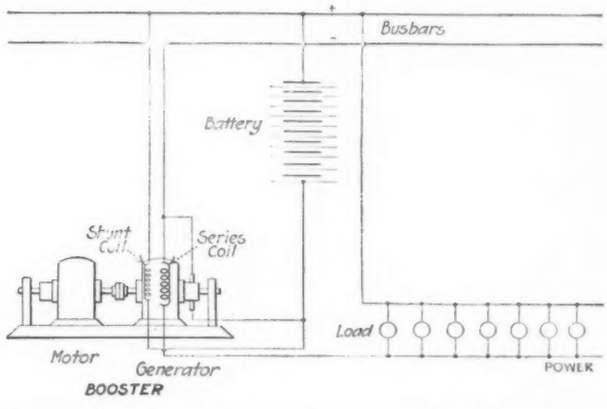


Fig. 4. Differential Booster with One Series and One Shunt Coil

The charging and discharging are for the most part automatic. However, owing to irregularities in the loads, it may be necessary at times to vary the excitation current in the shunt coil, or even to reverse it. A reversal is necessary when it is desired to cause the shunt coil to assist the busbar pressure in charging the battery instead of opposing it as at normal. A reversing switch is provided in the shunt circuit for this purpose.

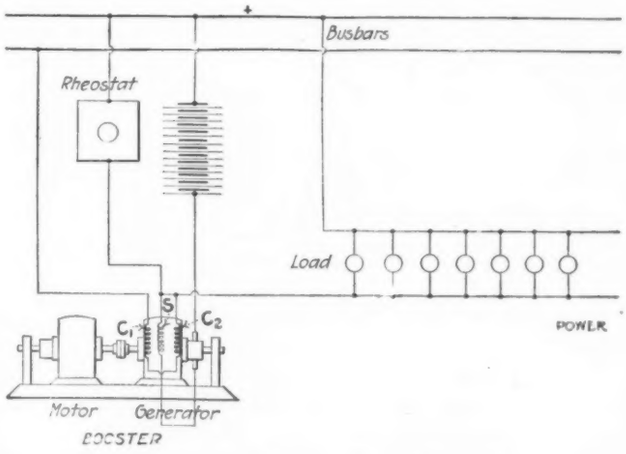


Fig. 5. Differential Booster with Two Series Coils

Differential Type

This type is of the automatic class and exists in several forms, one of which is shown in Fig. 4. This ma-

chine has a winding in series with one side of the station load. In addition to the series winding is a shunt coil connected across the battery. The latter winding is so wound as to produce a pressure in the same direction as that of the busbars, whereas the series winding tends to oppose the latter. On heavy loads, therefore, the series winding overpowers the shunt and causes the booster voltage to rise to a value which enables the battery to discharge and take part of the load. On light loads, the shunt winding overpowers the series, with the result that a charging current begins to flow into the battery.

The differential booster as most generally used is shown diagrammatically in Fig. 5, where S is a shunt coil which tends to cause the booster to act with the main pressure and send a charging current into the battery; C_1 and C_2 are series coils acting in opposition to the shunt coil. By the arrangement of the series coils, it will be seen that C_1 at all times carries the total load current flowing from the main supply source only, while the coil C_2 carries the total external load, including the part supplied by the battery. During periods of heavy load, therefore, the field produced by the coils C_1 and C_2, which coils act in the same direction, will overpower that of the shunt winding, thereby causing the booster to oppose the station voltage and assist the battery to discharge. As the load falls off, coils C_1 and C_2 become less active until a point is reached where the battery neither charges nor discharges. Below this point, the shunt coil overcomes the action of the series coils, with the result that a charging current begins to flow into the battery. The action is similar to that shown in Fig. 4, except that in the machine of Fig. 5 a more stable equilibrium is given to systems with rapidly fluctuating and widely variable loads. This is because coil C_1, producing a voltage opposite to that of the main busbars, tends to prevent a heavy current from flowing into the battery in case the voltage of the latter has been much reduced by a long-continued discharge. On the other hand, the coil C_1 renders a greater impetus to a discharge of the battery under a sudden heavy external load, thus relieving the station busbars from the necessity of taking all of the load and losing part of their pressure in consequence. By performing these functions, the coil C_1 tends to keep a more nearly constant load on the station busbars than would otherwise be maintained.

Operating Costs in a Power Plant

By W. G. Lighty

SYNOPSIS—Data on an office-building plant covering the cost of current, heating and elevator service. Results of a special test to determine the coal taken by the elevators.

A certain office building in Chicago, which is 72x150 ft. in plan by 16 stories high, was equipped with four return-tubular, hand-fired boilers 60 in. by 17 ft. Each was provided with a shaking grate having 25 sq.ft. of surface. Illinois Carterville washed nut coal was burned. The draft at the stack was 0.6 in., and 0.3 in. over the fire. Due to age, the general condition of the boilers and settings was poor and each year the working pressure, which was 90 lb. gage, was in danger of being reduced by the city inspectors.

A generating capacity of 300 kw. was installed. The load averaged about 30,000 kw.-hr. per month, or 360,000 kw.-hr. per year. This was divided about half and half between the building and the tenants, the current being sold to the latter at 7c. per kw.-hr. The building was heated by 30,000 sq.ft. of radiation.

Four hydraulic passenger elevators, each having a capacity of 2500 lb., served the building, two running to the sixteenth and two to the thirteenth floor. The elevator pumps consisted of a 14, 22 and 11 by 18-in. duplex and two smaller pumps having a combined capacity about equal to the large one.

On an average, 262 tons of coal were burned per month, or 3144 tons per year. At $2.65 to $2.70 per ton, the coal bill amounted to about $9000 per year. For labor, the annual expenditure was $6950, made up of wages to a chief engineer, three assistant engineers, three firemen and one oiler. The total operating expenses for an average year, as taken from the log, is given in Table 1.

TABLE 1. OPERATING COST PER YEAR

Coal	$9,000
Wages	6,950
Supplies	600
Repairs	1,000
Total	$17,550

Allowing 100 lb. of coal per square foot of radiating surface per season, the heating system would require, if run independently,

$$\frac{30{,}000 \times 100}{2000} = 1500 \textit{ tons}$$

This is practically half the coal, and from a fuel basis alone, would mean 13c. per sq.ft. of radiation. There are other charges, such as labor, upkeep, etc., of which the heating system should bear its share. Taking 25c. per sq.ft. as a fair rate (it would be more than this if obtained from a central heating plant), the charge against the heating system would be $7500.

It was proved by test that the elevators were responsible for 35 per cent. of the coal consumption, and taking this percentage of the total expense, the annual charge against the elevators is $6142.50. Deducting this amount and the charge for heating from the total leaves

$$\$17{,}550 - (\$7500 + \$6142.50) = \$3907.50$$

as the charge against the generation of current. Per kilowatt-hour, this reduces to

$$3907.50 \div 360{,}000 = 1.085\text{c.}$$

The plant should then be credited as indicated in Table 2.

TABLE 2. CREDITS TO PLANT

180,000 kw.-hr. at 1.085c.	$1953.00
180,000 kw.-hr. at 7c.	12,600.00
30,000 sq.ft. radiation at 25c.	7,500.00
Elevators, 35% annual expense	6,142.50
Total	$28,195.50

This gives a profit to the plant of

$$\$28{,}195.50 - \$17{,}550 = \$10{,}645.50$$

Taking it another way, the cost of current to the tenants might be deducted from the total expense, and the charge to the different departments lessened in their proper proportion.

Due to the condition of the boilers, it was a question whether to reduce the pressure and use them for heating, change the elevators from hydraulic to electric and use purchased current, or to install new boilers. To determine this point, a day was set aside to test the elevator plant and learn as closely as possible the amount of coal required, the volume of water pumped, the passengers carried, the horsepower developed and the cost per car-mile for coal. The test was started at 7 a.m., and continued until midnight. The results are plotted in the accompanying chart.

One boiler was designated to supply the steam, and the large duplex pump was used. The usual operating pressures and schedule of running were followed. The boiler pressure was 90 lb. gage, and the pump worked with an initial steam pressure of 73 to 75 lb. against a back pressure of 2½ lb. The water pressure was 150 lb. No. 3 elevator was operated from 7 a.m. to midnight, No. 2 from 7:30 a.m. to 6:30 p.m. and from 7:50 p.m. to 9:28 p.m., No. 1 from 8:38 a.m. to 6 p.m., and No. 4 from 9:10 a.m. to 5 p.m. The number of passengers up and down was recorded every 15 min. The gallons of water pumped were obtained by recording the number of strokes of the pump, a special counter being fitted up for the purpose, and measuring the length of stroke to obtain the average. The coal and water fed to the boiler were weighed. The evaporation of water per pound of coal as fired was 5.17 lb., or about 6 lb. from and at 212 deg. Ordinarily, better results were obtained, but during the test a 100-hp. boiler was carrying on an average only 65 hp., whereas it had been the practice to operate the boilers at 30 per cent. overload. In Table 3 is given for each hour the car-mileage, the cost of coal and the cost per car-mile. In the chart number of passengers should be read at the end of each 15-min. period, but the other items, such as coal and water, were plotted in hourly quantities, so that the reading from the curves should be taken at the end of each hour.

TABLE 3. COST OF COAL PER CAR MILE

	a.m.									p.m.						
Time	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
Car mileage	1.22	3.52	5	4.86	4.79	4.56	5.33	4.86	4.45	5.04	4.25	2.75	1.99	1.86	1.40	1.08	0.53
Coal per hr., lb	315	360	390	330	390	320	390	395	400	310	390	305	300	295	125	125	50
Cost of coal, c	42.05	48.06	52.06	44.05	52.06	42.72	52.06	52.73	53.40	41.38	52.06	40.72	40.05	39.38	16.69	16.69	6.67
Cost per car mile, c	34.47	13.65	10.41	9.06	10.87	9.37	9.76	10.85	12	8.21	12.25	14.81	20.12	21.17	11.92	15.45	12.59

As given in Table 3, the car-miles for the 17 hr. per day which the cars were run, totals 57.41; on some days the mileage was greater. During the year in which the test was made the total mileage was 25,632. The cost for coal averaged 13.94c. per car-mile. In the morning, when the load was light and the trips less frequent, it ran as high as 34.47c. and during the peak load at 5 p.m. it dropped to 8.21c. The average cost for the nine busiest hours, 9 a.m. to 6 p.m., was 10.31c. per car-mile.

As stated, the elevators are responsible for 35 per cent. of the coal. The annual cost was $9000 and the above percentage of this is $3150. Dividing by the mileage per year gives 12.3c. per car-mile. If 35 per cent. of the entire operating cost of the plant were charged to the

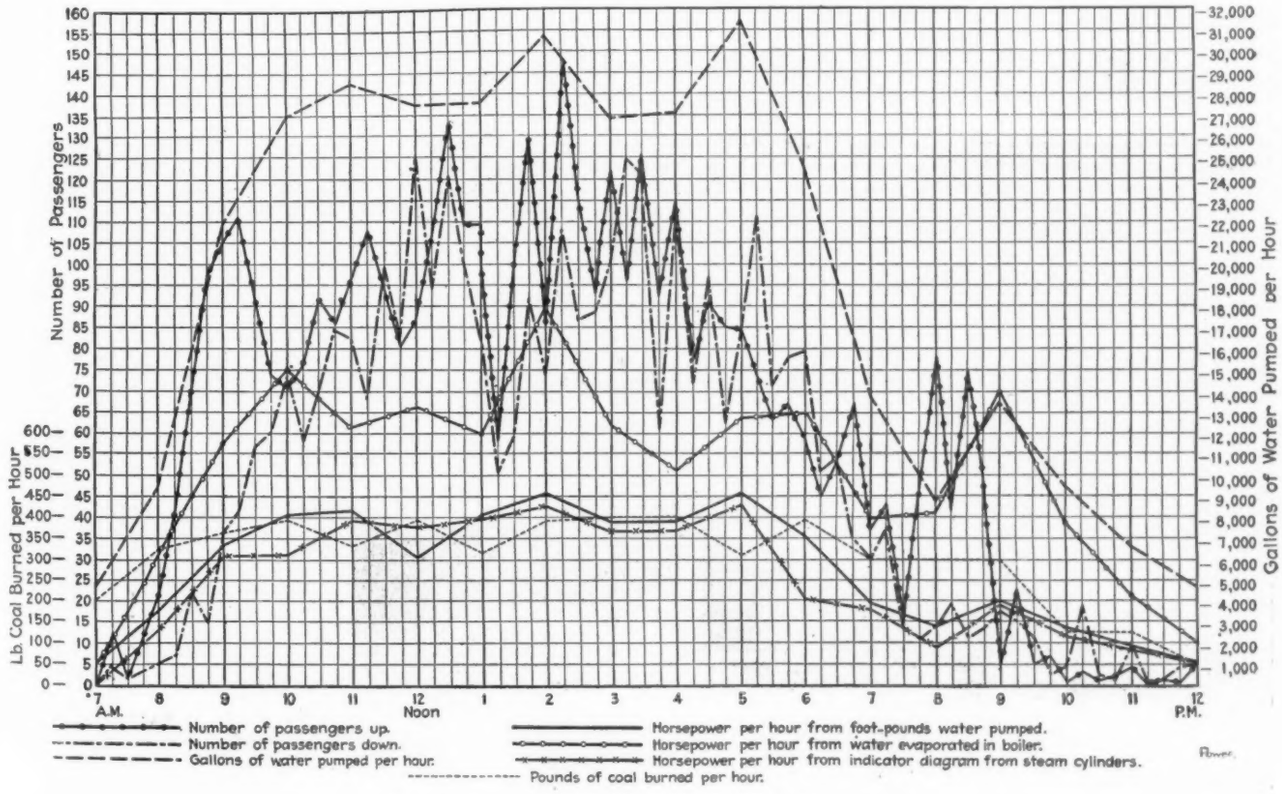

Number of Passengers
Lb. Coal Burned per Hour
Gallons of Water Pumped per Hour
A.M.
Noon
P.M.
Number of passengers up.
Number of passengers down.
Gallons of water pumped per hour.
Pounds of coal burned per hour.
Horsepower per hour from foot-pounds water pumped.
Horsepower per hour from water evaporated in boiler.
Horsepower per hour from indicator diagram from steam cylinders.

CHART SHOWING OPERATING TEST OF ELEVATOR

elevators, the rate would be nearly 24c. per car-mile. This includes the upkeep of the cars, except cabling, but not the wages of the elevator operators.

It may be of interest that as a result of the test two new 130-hp. boilers were installed to take the place of the old boiler plant. With the same electric load and an increase in the elevator load, a saving of 23 per cent. in the coal bill was effected the first year.

An Old-Time Engine

By R. H. Porter

The oldest steam engine in use in central Iowa, and perhaps in the state, is owned and used by the Madrid Milling Co., Madrid, Iowa. It was hauled by wagon from Keokuk to a place a few miles north of Madrid in 1855, and ran a sawmill. In 1868, the engine was brought to Madrid and operated in a grist and sawmill. When it came into the hands of the present owners it ran a flouring mill.

The old engine has been in constant operation since its arrival in the state and has outlived four boilers. To see it running today, one would hardly realize it has almost 60 years of service to its credit. There is no name-plate or mark by which to identify the manufacturer. As to its steam economy, there is nothing to say.

The cast-iron bed is made in four sections, bolted together at the corners, and is about 12 ft. long and 18 in. wide. The 8x22-in. cylinder is not lagged to retain its heat. The valve chest containing the simple D-valve is bolted to the top of the cylinder. The 2-in. steel piston rod is keyed to a cast-iron crosshead, the shoes of which

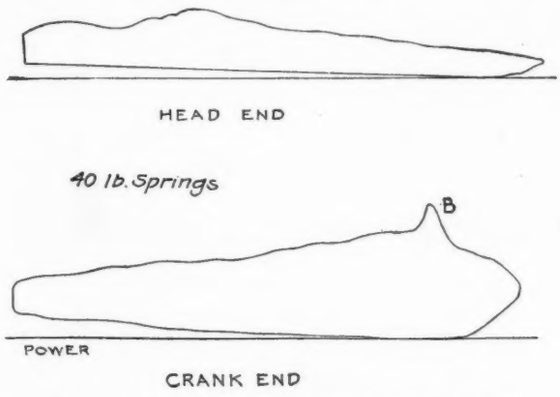


Fig. 2. Diagrams Taken from Engine

are of hickory and have to be replaced about every two or three months. Originally, the valve rod was of one piece, but owing to the cutting of the packing a knuckle joint was used.

One of the interesting features of this old engine is the attachment of the eccentric rod to the rocker-arm,

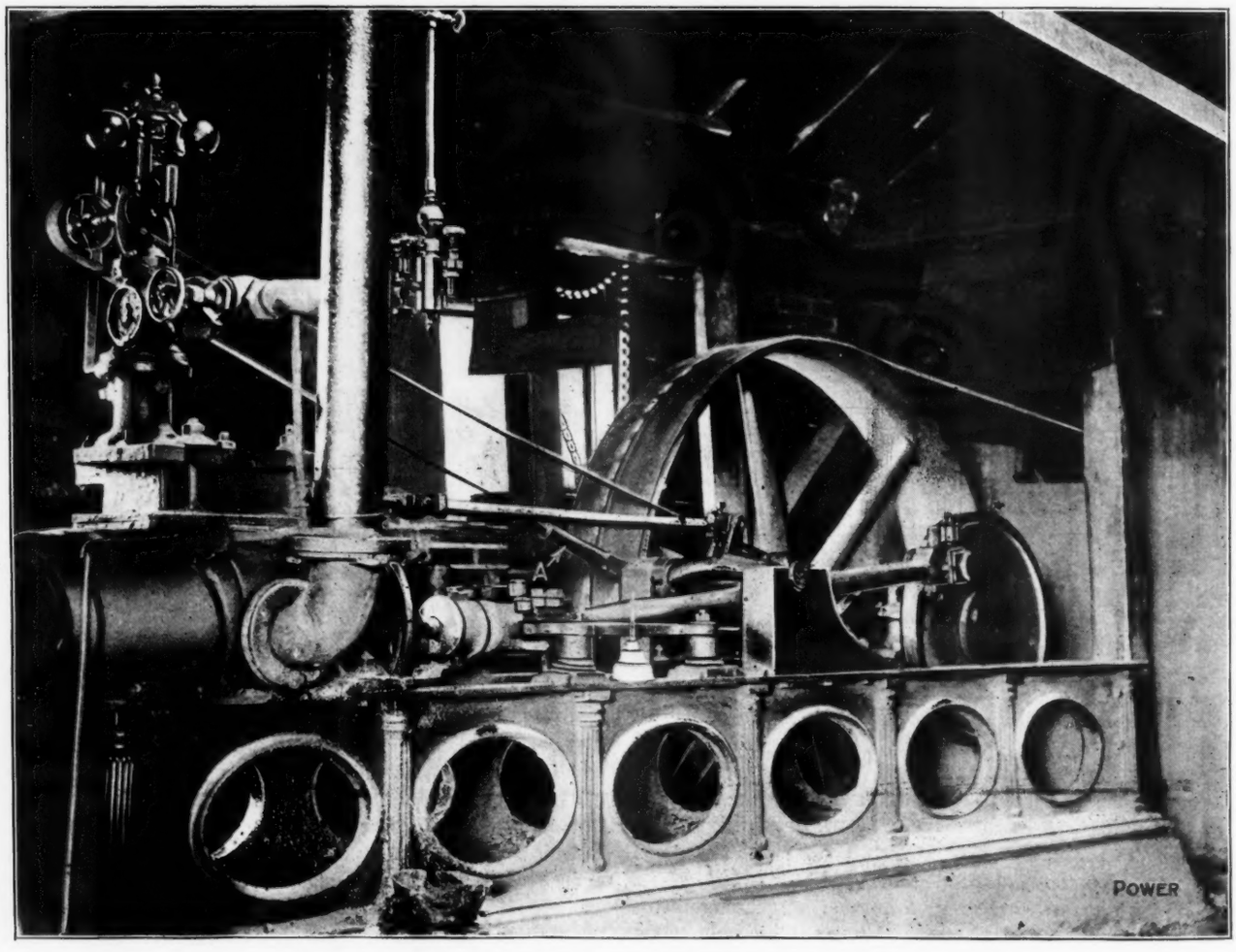


Fig. 1. Engine with 59 Years of Service to Its Credit

the connection being the same as that on some of the early Corliss engines to connect the reach rod to the wrist plate, having only a slot in the arm. On the rocker-arm is a lever *A*, Fig. 1, about 2 in. in diameter and 18 in. long, which was used to work the valve and free the cylinder of water before the drain connections were put on.

The 5-in. crankshaft is of cast iron and about 5 ft. long. No evidence of being trued up in any way is shown on the cast-iron flywheel.

Two diagrams, Fig. 2, were taken from the head and crank ends, respectively, as the engine was running in the summer of 1912. The indicator was attached to the cylinder through the drain-cock openings and the peak at *B* was due to a slug of water coming into the indicator; the diagrams figure 13 i.hp. at 105 r.p.m.

The engine is throttle governed, steam being supplied by a 3-in. main, and the exhaust is 4 in. in diameter. The governor, lubricator and grease cups are modern additions to the engine.

Testing and Adjusting Steam Gages

By F. W. Bentley, Jr.

SYNOPSIS—A practical article dealing with the testing and adjustment of the Bourdon-type pressure gage. Tells how to construct a testing outfit from fittings found in the stock room of almost any plant. Test for correct readings at all pressures; what to do when a gage registers uniformly high or low. Correcting a gage in which the error increases as the pressure becomes greater. Taking up lost motion. Refinishing the face of the dial.

Testing and adjusting the dial pressure gage for accuracy is a frequent necessity. A suitable testing apparatus is another necessity which many plants do not possess. In Fig. 1 a home-made device is shown which will answer all requirements; it is not so elaborate as many of the higher-priced arrangements, yet any ordinary gage can be carefully set and adjusted with it. Ordinarily, the only part which need be purchased is the adjusting or monitor gage *A*. The barrel or pressure cylinder of the device is simply a piece of 2- or 3-in. pipe bored out with a cut sufficiently fine and clean to enable the piston leather to hold the oil as it is compressed by the screw to register the pressures on the gages. The rest of the apparatus is, for the most part, simply ¼-in. pipe fittings, all of which are a part of any plant's repair stock.

As the majority of gages now used are of the Bourdon-tube type, the following description applies to such gages. The provisions for adjustment on any type of gage, however, are much the same, all principles of operation being practically alike:

Assume that we have a gage for test and comparison with the monitor gage of the testing device. If the pressure registers the same at all graduations and the hand of the gage under test is sensitive to all slight movements of the ram spindle, we need go no further. A common defect is to have the gage under test continually show an excess in registered pressure over that of the monitor. If this excess is constant at all pressures, a resetting of the hand is all that is needed to correct the gage for use again.

Take a case where the gage is so defective that it may require not a little experimenting and adjustment to make it register perfectly at all points on the dial. Suppose the gage shows this defect, that at 10, 20 and even 30 lb. resistance against the plunger, it registers perfectly with the graduations on the monitor gage, but at 40 lb. reads a trifle in excess of what it should, say, 2 or 3 lb. At 50 the hand may be in advance to an error of 5 lb. The writer has adjusted gages which at 150 lb. showed as much as 20 lb. in excess of the pressure shown at that point by the monitor. This action plainly shows that the hand is traveling too far for the corresponding amount of expansion of the pressure or expansion tubes

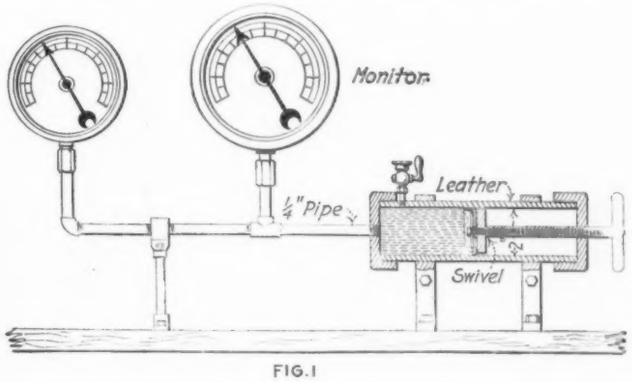


FIG. 1

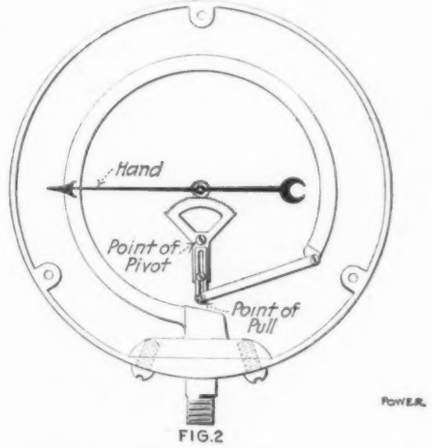


FIG. 2

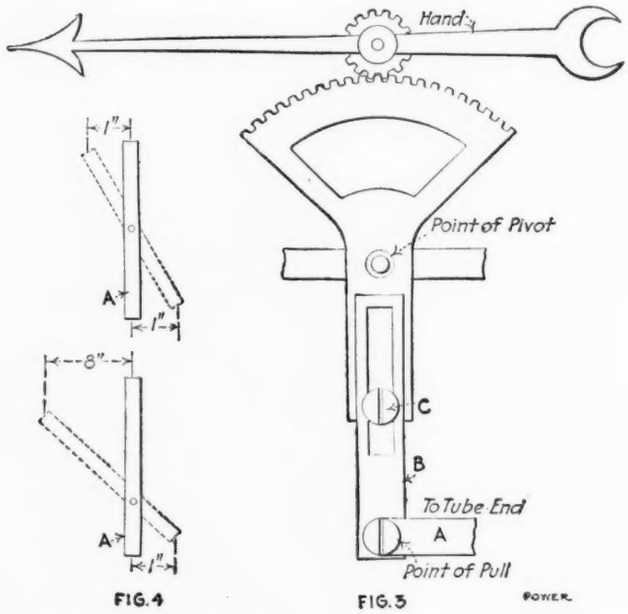
Showing the Test Pump and Gage Mechanism

of the gage as the plunger increases the amount of resistance within them.

Fig. 2 is a sketch of the general interior of the average gage, but the provision for adjusting and correcting the above defect can be more clearly understood by reference to Fig. 3. The pull rod *A* is attached to the lower end of the gear segment through the small slide *B*. The screw *C* allows the slide to work up and down on the body of the segment. This brings the point of pull further away from or closer to the point of pivot.

The object of this provision may be understood more clearly perhaps by reference to Fig. 4. We have a strip of wood through which we place a pin as an axis at its exact center. Now, if we move the end *A* through a space of 1 in., we get a movement of 1 in. at the other. We place the pin closer to the end *A* and again give it a movement of 1 in. This time the free end of the stick moves much further. This illustrates the same principle of the purpose of the slide on the segment of the gage. If we loosen the screw *C*, Fig. 3, and move the slide up, we get a greater arc traveled through by the toothed portion of the segment. Moving the slide down brings the point of pull further away from the point of pivot and results in a lesser travel of the segment and consequently a reduced amount of register by the small pinion controlling the gage hand.

As we cannot adjust the hand travel with the dial of the gage in place, we must resort to other means for keeping the register marks continually in view during the process of correction. Before removing the dial, small nicks must be made in the thin edge of the gage casing, directly above or opposite the graduations on the dial when the dial is in place. The amount of pressure these little nicks indicate is marked with chalk near them, as shown in Fig. 5. When the dial is removed and the hand is temporarily applied for adjustment, we have something to guide us as the slide is moved up and down to bring the travel of the hand to its correct travel with the corresponding tube expansion to register correctly at all



GAGE MECHANISM, SHOWING ADJUSTING SCREW *C* AND DEFLECTION OF GEAR SEGMENT

graduations. After this has been accomplished the hand is removed, the dial applied and the hand reset.

Lost motion caused by the wear of the holes through the small connecting levers is another trouble which can be easily remedied. These holes can be closed a trifle with the peen of a small light hammer. A fine rat-tail file will enlarge them well enough to again take the body of the tap screw with all lost motion eliminated. Lost motion has no evil effects on the gage to speak of if the adjustment is correct, yet at the same time it is an easy matter to remove it; this operation lessens quivering of the hand should the gage be subject to much vibration.

The gage dial is often subject to the effects of heat and moisture, which in time corrode it, making the face figures sometimes almost indistinguishable. The paint or enamel down in the figure recesses will crack and fall out

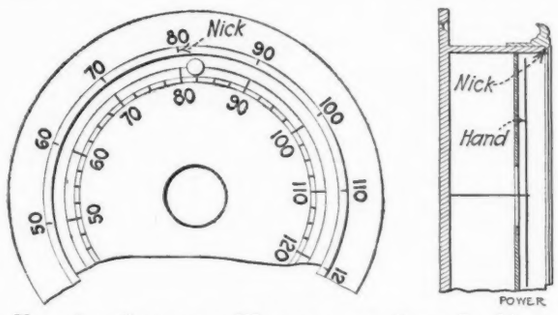


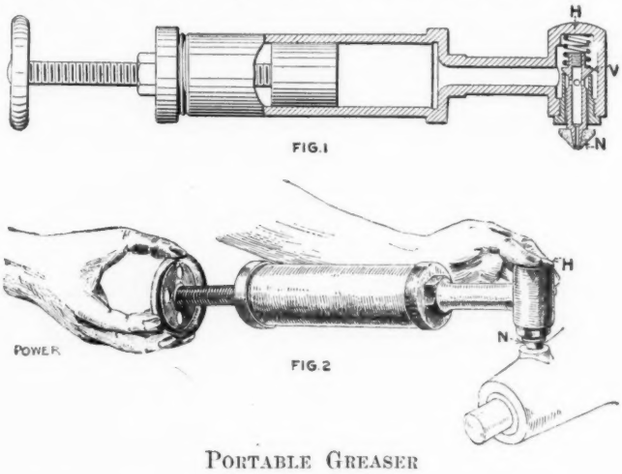
FIG. 5. SHOWING WHERE THE CASE IS MARKED DURING TEST

from the effects of heat and moisture. The gage-dial face is best cleaned with finely powdered glass and oil.

In retouching the figures, the following is an excellent method: the paint should be daubed thoroughly into the sunken portions of the dial, and the surplus wiped off with stiff porous paper. The paper, being flat and stiff does not disturb the paint in the figure recesses, but in cleaning the remainder of the dial it leaves the graduations clear and distinct.

Portable Greaser

The appliance illustrated herewith was designed by John C. White, who is in charge of the Capitol Power Plant at Madison, Wis., for the occasional application of grease to small bearings which it is not desirable or con-



PORTABLE GREASER

venient to equip with compression cups. The grease is put under pressure by screwing the plunger down upon it. The grease holes of the bearings are cupped as shown to receive the conical nozzle. With the nozzle in place, as in Fig. 2, the hand is pressed upon the head *H*, forcing the valve *V* open against the action of the spring, and allowing grease to escape under pressure into the bearing. In this way grease may be used with all the handiness and with much more cleanliness and positiveness of application than oil with the ordinary can. It is not upon the market, nor even patented, and anybody is free to make and use it.

Editorials

Adamson Water-Power Bill

At last definite action upon the water-power situation seems assured. Several bills pertaining to this subject have been introduced in the present Congress, but their shortcomings have been such as to bring about their defeat. The Adamson bill, however, which passed the House of Representatives on Aug. 4, as an amendment to the "General Dams Act," is now before the Senate, and as it is understood to have the backing of the administration, its passage is looked for. In its present form, it appears to reasonably safeguard the interests of the public, at the same time maintaining a fair attitude toward the power companies. Presumably the Senate will offer several amendments, but in doing so it is hoped that some of the loose provisions will be strengthened rather than any of the meritorious features eliminated. The principal points of the bill may be summarized briefly as follows:

There are the usual provisions for safeguarding navigation, and after a grant has been made for power development, complete plans of the project must be submitted within two years. The project must then be completed within three years after the plans have been approved unless, for some very good reason, an extension of time is granted by the Secretary of War. Also, it is the duty of the latter to see that development proceeds as fast as the demands of the available market warrant. This clause, if carried out, would effectively prevent the holding of undeveloped water powers for monopolistic purposes.

Grants under this act would be for a period of 50 years, at the expiration of which, or any time thereafter, the government could take over the property at a fair value, taking into account depreciation, but excluding such intangibles as going concern, good will, franchise value, etc. In case of dispute as to a fair valuation the courts would decide.

At the discretion of the Secretary of War, it may be stipulated in the grant that the grantee shall pay the government an annual rental, and at the end of 20 years and every 10 years thereafter the charges may be readjusted. While the wisdom of charging for such privileges has often been questioned, since they are usually passed on to the consumer in the form of higher rates, still it is well to give the Secretary of War this power, to invoke as special conditions may warrant.

In leasing the use of surplus water from dams constructed by the Government for purposes of navigation, preference is to be accorded to municipal projects or other corporations not operated for private profit. Moreover, it is specifically stated that no rights under this act shall be owned or controlled by any combination in the form of an unlawful trust to limit the output or sale of electricity. Violation of this provision will mean forfeiture of the grant. However, the Secretary of War may approve of interconnecting systems for economically handling loads providing the energy is properly accounted for.

The regulation of service and rates is left to the states, except in the matter of interstate business or where adequate state regulation is not provided; in such cases this duty falls upon the Secretary of War, who in fixing rates shall not consider intangible values.

None of the provisions of the Adamson bill are intended to apply to any water-power grants on public lands of the United States under the jurisdiction of the Department of the Interior or the Department of Agriculture.

Opponents of the bill argue that at the end of 50 years, should the Government desire to regain possession of a water power, it would have to take over the whole system served. Moreover, they point to no provision for publicity of accounts, although, it is clearly specified that all books shall be open to inspection by the Secretary of War or his duly authorized agents.

While we believe the Government should encourage the cheap production of power, there are several cases at present in which a large part of the hydro-electric energy is sold to a steam-operated system and the steam power determines the price to the consumer. There is apparently nothing in the bill to prevent this, in which case relief would have to be sought through the state commissions.

Although not ideal, we are inclined to believe that the merits of the bill as it now stands outweigh its defects. Although it might appear to place too much power in the hands of the Secretary of War, yet, viewed from another angle, this is desirable in that it fixes responsibility and such an official who violated this confidence would have to account to the public.

CO_2--A Tool

Many engineers and firemen seem worried because they think they do not understand what CO_2 is. They are told that it is a gas consisting of one atom of carbon and two of oxygen, but this explanation is not enough; it is not satisfying. To such men there is a chemical mystery about the whole thing which they feel they should understand to the fullest if they are to get the most out of a pound of coal.

The technical press, engineering organizations, educational work, conversations among power-plant men, all have treated of the gas CO_2 until it would seem that the relation of this gas to boiler-room practice was common knowledge even to coal passers. In reality, however, the effect of all this published and talked-about matter has been to confuse many operating men, just as one gets confused trying to miss nothing at a three-ring circus.

It is no more necessary to the best results from the burning of coal in a boiler furnace that the fireman shall understand all there is to the chemistry of the flue gases, than it is essential for a gardener to have a thorough knowledge of the scientific aspects of heat and light in order to successfully grow plants or vegetables in a hothouse. When one looks at a steam-pressure gage he has in mind pressure; he does not worry if the steam

whose pressure is indicated or being recorded is dry saturated or superheated, or whether the entrained water in it is acid or alkaline.

Pressure is the thing we want to know about, and on its amount as compared with what it should be we can locate troubles indicated by an increase or decrease.

In this case, we use pressure as a tool, so to speak; and that is the way to use CO_2 readings on the burette of an Orsat or the chart of a CO_2 recorder. The all-important thing to know is that, if the boiler can be worked as hard as desired and 10 to 15 per cent. CO_2 maintained in the flue gases at the uptake, the combustion is good. A man who had made ever so thorough a study of chemistry and CO_2 in particular could get little or no better results in coal consumption per pound of water evaporated than if he knew only the above simple fact. If the CO_2 readings are low—and readings below 8 per cent. may be considered low—then the furnace is getting too much or too little air—usually too much. Whether too much or too little, it is easy to find which it is, and any man with normal reasoning power and common boiler-room experience will soon ascertain why it is too much or too little. The CO_2 readings are merely a means to this end. They tell him which way he is going, whether his firing and combustion-control methods are for better or for worse, and this is the chief thing in boiler-furnace practice.

The more a man knows about boiler practice the better use he can make of CO_2, and the more he investigates to find out why CO_2 readings are high or low, the better he will know how to run a boiler.

Combining Flood and Power Dams

In a recent editorial, the *Dayton News* questions the wisdom of omitting power development in connection with the proposed reservoirs for flood protection in the Miami Valley. An account of the Wolfelsgrund Dam in Prussian Silesia, printed in the *Engineering Record* for May 30 is cited as one in which the dual purpose of flood prevention and power development are successfully combined. An editorial in the same issue of the *Engineering Record* is also quoted as follows:

> It is plainly an error to dismiss the possibility of a dual purpose dam without adequate consideration.

The *News* failed to quote, however, what the *Record* said in the forepart of the same editorial:

> Contrary to views frequently expressed in this country, the construction of double-purpose dams is not necessarily an engineering mistake.

This does not say, however, that it is frequently possible to combine the two functions in one dam.

Much as we are interested in the development of water power, we are compelled to admit that there are more cases where the two functions cannot be combined than where they can be, and this is better understood when it is considered what the two functions are and how incompatible they are.

The purpose of a flood dam is to hold back the water in time of heavy rainfall to a rate of discharge that is not productive of damage; but the aim is to get rid of the water as fast as it can be discharged safely, so that the dam may be in readiness for the next flood without being unnecessarily large.

A power dam, on the contrary, is for accumulating water during the rainy season against the time when the stream flow is at its lowest ebb, and thus keep the flow as near as possible to its average value throughout the year. Naturally, if a flood came during the time that the reservoir was full, there would be no flood protection. The situation would be just as bad as though there were no dam, so that for the dam to combine the two functions it would have to be probably twice as large as it would for either purpose alone.

Where there is no trouble from floods, dams can be built for power purely, but where there is flood difficulty it is quite a question if the power feature should enter in, on account of the greatly increased cost.

It is impossible to deal in generalities in questions such as this; they must be settled for each specific case. If sufficient head can be secured and sufficient power developed to warrant the expenditure for the land which must be condemned and the type of dam which must be constructed, then the dual-purpose dam is justified, but only then.

A flood dam is a benefit to any power developments lower down in the valley, if there are any, in that it saves to them a lot of water which would be wasted if it came down in time of flood, because of being in excess of the quantity they could handle; but how much this benefit amounts to, depends on the capacity of the flood reservoir, and how long it holds back the surplus water; in other words, how nearly it maintains an average flow.

While the *Engineering Record* is doubtless right in saying that it is an error to dismiss the possibility of the dual-purpose dam without adequate consideration, it is also plain that the "adequate consideration" needs emphasis, for it is a decided mistake to undertake the construction of a dam to combine both purposes without carefully weighing all questions bearing on its utility and cost.

Proper Tube Expanding

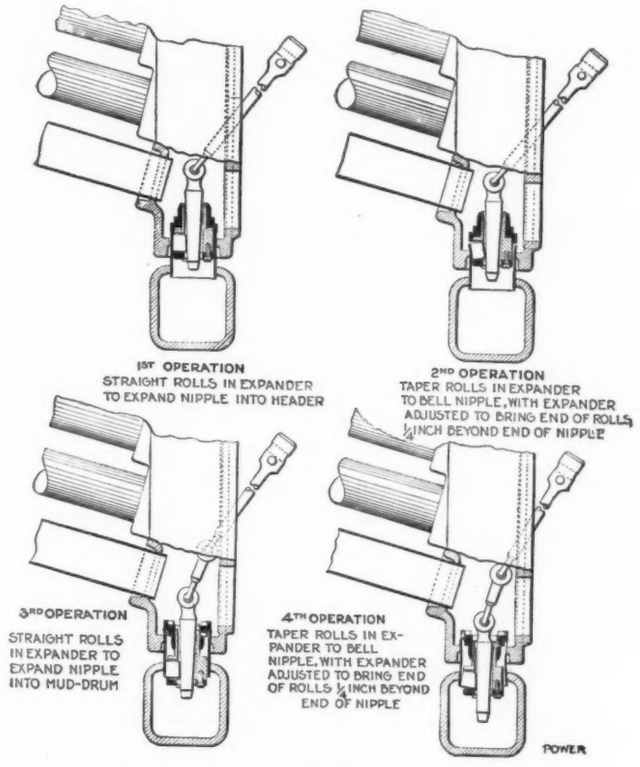
A most important subject is treated by an authority on page 245 of this issue. Too much stress cannot be put on the need of the utmost care in expanding the tubes into boiler drums and headers. Where possible it is always better to have the work done by an expert boiler maker; large plants usually have one on the payroll and small plants should call one in when needed. However, emergencies may arise when the job must be done without expert help, and, in any event, it is well for anyone having to do with boilers to know how the work should be done whether he has to do it himself or not. No matter how familiar such a one may think himself with the proper method of tube expanding, we earnestly recommend that he read the letter by Mr. Wells, not once but as many times as may be necessary to thoroughly understand the how and the why of the directions given. Finally pass it around the plant or post it where "he who runs (the boilers) may read."

The annual report handed to the chief engineer of power plants of the Boston Elevated Railway Co. shows a coal consumption of 1.744 lb. per kw.-hr. for last year, (year ending June) total output from the South Boston Station. This figure allows for all losses. Who is getting better results?

Correspondence

Proper Tube Expanding

The issue of June 9, page 838, described an explosion at the plant of the Detroit United Rys., New Baltimore, Mich. A wrought-steel mud drum blew off the nipples, according to the article, due to the tube holes in the mud drum being somewhat tapered, which condition was brought about by the use of a worn and somewhat tapered cutter.


1ST OPERATION
STRAIGHT ROLLS IN EXPANDER TO EXPAND NIPPLE INTO HEADER
2ND OPERATION
TAPER ROLLS IN EXPANDER TO BELL NIPPLE, WITH EXPANDER ADJUSTED TO BRING END OF ROLLS ¼ INCH BEYOND END OF NIPPLE
3RD OPERATION
STRAIGHT ROLLS IN EXPANDER TO EXPAND NIPPLE INTO MUD-DRUM
4TH OPERATION
TAPER ROLLS IN EXPANDER TO BELL NIPPLE, WITH EXPANDER ADJUSTED TO BRING END OF ROLLS ¼ INCH BEYOND END OF NIPPLE
POWER

INSTRUCTIONS FOR EXPANDING TUBES

As soon as we learned of this accident, the Babcock & Wilcox Co. sent an engineer to New Baltimore, and found, first, that the mud drum was put in place by employees of the Detroit United Rys. on or about Mar. 20, 1914; second, that the expander used was equipped with straight rollers only; third, that the ends of the nipples did not extend properly through the tube seats of the mud drum and were not flared; fourth, that in expanding these nipples, the lower ends of the expander rolls did not pass through the nipple seats, and that it was this operation which caused these seats to become tapered.

The accompanying sketches show the proper way of expanding mud-drum nipples, and also give explicit directions. One expander and both straight and tapered rolls are required. There are four operations:

First—Expand the nipple into the header. Use straight rolls centered at the header seat.

Second—Bell the nipple in the header. Use tapered rolls adjusted to bring the ends of the rolls ¼ in. beyond the end of the nipple.

Third—Expand the nipple into the mud drum. Use straight rolls centered at the mud-drum seat.

Fourth—Bell the nipple in the mud drum. Use tapered rolls adjusted to bring the ends of the rolls ¼ in. beyond the end of the nipple.

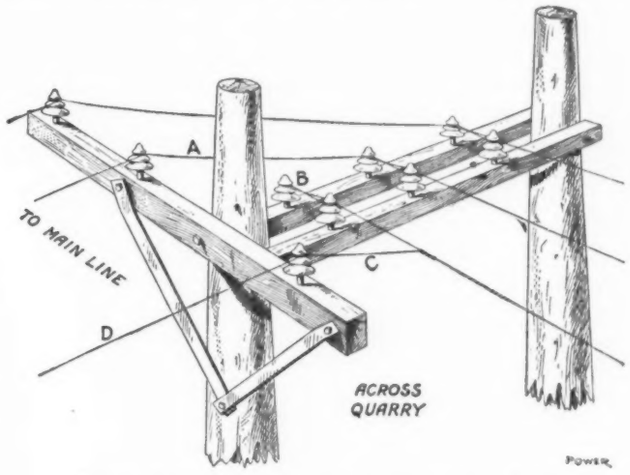
We shall be glad if you will publish this letter, together with a cut, as such publication will give to your readers correct information in regard to this most regrettable accident, and, in addition, may be the means of preventing similar accidents in the future.

E. H. WELLS,
President, the Babcock & Wilcox Co.
New York City.

Blackbird Cripples Power Line

A blackbird, only 8 in. long from tip of tail to end of beak, caused a short-circuit on a 22,000-volt transmission line at the National Limestone quarries, Martinsburg, W. Va. Where this line crosses the quarry cut, it makes a 500-ft. span and turns at nearly right angles from the double post connection, as shown in the sketch.

The weight of the wires had caused the middle insulators to sag over and pulled the middle wire *A* to about 6 in. from the insulator having the outside wire *B* attached. Evidently on alighting on the wire *A*, the bird



RIGHT-ANGLE TURN OF TRANSMISSION LINE

had rocked to get its balance and came close enough to cause the current to jump the remaining distance, causing a short-circuit, which continued to burn after the bird had dropped off, until about 2 ft. of wire was consumed. Wire *B*, which is the dead end of the first wire crossing the quarry, is wound on the two insulators with a figure 8, and was burned in two, it being held up only by the connection to wire *D*.

This power line furnishes electricity to about 1040 hp. of motors and the short-circuit also caused the shutdown of two other plants connected in parallel with it; the latter for only a few minutes until the main-line switches could be thrown, cutting out the disabled line. It took about two hours to repair the burned wires.

The old saying that troubles never come singly proved true in this instance, as a few hours later a steam pump blew out a plug in the water end and drenched the motor which was driving a centrifugal pump, causing it to burn out two coils in the field before the fuses blew. Three hours more were lost in cutting out the burned coils and putting in jumpers. The pump is now running the same as before minus two coils.

C. L. MALLERY.

Martinsburg, W. Va.

Brass vs. Babbitted Bronze Boxes

I think Robert P.Harris is right in his letter on page 861, June 16. The edges *CC*, Figs. 1 and 2, should have been filed or planed off evenly until the brasses were a nice fit to the crankpin, and the shims *BB*, Fig. 3, put in each side of the brasses to keep the distance between the centers the same.

Babbitted iron boxes are used on some stationary engines, but if the iron comes in contact with the pin it will be badly scored before the engine can be stopped. To prevent cutting the pins, babbitt-lined boxes are used, but they are often found too soft for good service, and wear away rapidly under heavy overloads. Babbitted brass or iron boxes are much cheaper in first cost than bronze. They may be fitted to the pin by free use of oil to keep them from getting too hot while running only a few hours at a time until it bears evenly all over, when it will then cool down, and after being taken out and the edges trimmed it will give no further trouble.

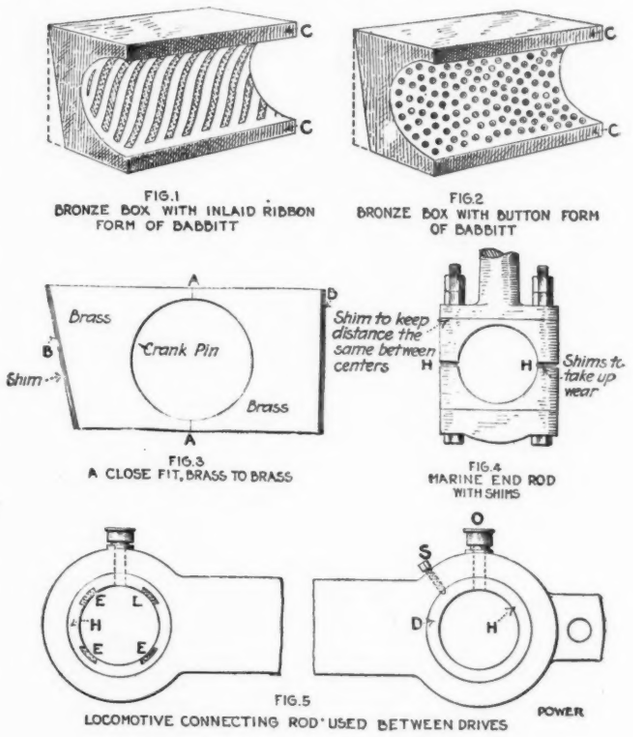
There are conditions in some plants where it means much damage if the machines cannot be freed from the stock that is going through before they are stopped. What would happen to a cold-storage plant if the compressor had been stopped suddenly without being pumped out, as in the case of a hot crankpin if the ordinary babbitted brass or iron box was used?

The bronze boxes illustrated in Figs. 1 and 2 will prevent such possibilities. Phosphor bronze is used on the crosshead pins and babbitted bronze on the crankpins and bearings of large engines and compressors. Bronze wears well on the crosshead pins, but being made of copper and tin, is too hard for either crankpin or main bearings without being babbitted. The babbitt equals about two-fifths of the surface, which causes the bearing to run with less heating. The brass box is made of copper and zinc, and is much softer and not suitable where the engines must be kept running after the babbitt has been melted out. The ideal bronze has a temper midway between phosphor bronze and brass.

Most engineers object to using either bronze or babbitted bronze boxes, because they must be kept keyed up closely, for with the same amount of slack they will make more noise.

When a bronze box is put on, the pin should be smooth and true, the box fitted perfectly, and the engine in perfect alignment. The high spots on the bronze surface cannot be worn off by running the engine. For this reason, it requires a skilled mechanic to fit them, and they must have a liberal supply of good oil until worn down to a good running fit, which may require a week or more.

When well taken care of, there are no better running boxes, and they will last a life time when properly fitted, if they get enough good oil. Most bearings wear or are melted out through being keyed up too tight, gathering grit or having insufficient oil. I prefer not to use oil channels; they collect dirt and, when filled, cause heating. Less oil will be thrown from the bearings when they are run brass to brass as in Fig. 3, at *AA*, enough being filed off the edges to allow the bearing surfaces to just fit the pin. Keying up tight in this way prevents wear on the rod end and avoids many hot boxes. The choice of methods in fitting boxes is usually left to the engineer. Many stationary-engine builders make boxes with



TYPES OF BABBITTED BOXES

a clearance at *AA*, to allow keying up in a few minutes, while the marine engines have a bolted stub end with removable shims *HH*, Fig. 4.

In this type, when the wear equals the thickness of one shim, it is removed and the bolts tightened up. Shims can be used at *AA*, Fig. 3, but in some cases the bearing edges of the brasses are not of sufficient area to clamp them in so that running brass to brass holds the box more rigidly. I have run engines with bronze boxes like Figs. 1 and 2, both with and without oil grooves. When they get hot I use a little graphite or flour of sulphur to keep them from cutting and to smooth up the bearing surfaces. White lead will help when nothing better is at hand. Much depends on the system of oiling.

In some cases, such as on locomotives, it is impossible to get extra oil on the pins while running, and the engine must be kept running to reach a siding. Only a few locomotives have adjustable boxes on the rods. They are

generally solid ends with babbitted bronze boxes, forced in the rod ends under pressure and held by setscrews; they are made in the form of bushings. Fig. 5, *D*, is the bushing, *S* the setscrew, *O* the grease cup; and *EEEE* the babbitt. They are so made because each time a box is keyed it changes the rod length between centers and causes strain when the pins are passing the centers. Hence they will heat, even though they may be loose on the pin. If the locomotive bearings were fitted nicely, as for stationary service, they would heat in a short time and melt the babbitt. With the solid end rod and the bushing type of box, this does not often happen. When worn, the bushings are replaced with new ones.

Some stationary engineers recognize the advantage of the brass-to-brass method of operation, and remove the boxes and file off the edges each time they are taken up. I am still using the bronze babbitted boxes which were originally furnished with the engine. I prefer the button type of babbitt, as it wears much longer, runs smoothly, and is easy to keep tight on an overloaded engine.

R. A. Cultra.

Cambridge, Mass.

Babbitt bearings are good in places where a continuous supply of oil is impossible, for the reason that, should the wearing surfaces get dry, the babbitt will wear without much increase in friction; and further, in case the bearing gets so hot that the babbitt will run, the journal is in no danger of getting injured. A bronze bearing, however, properly made, fitted and lubricated, will outlast a babbitt bearing under the same conditions.

Some claim that babbitt has a lower coefficient of friction than bronze. While this is not true with some bronze, it does not make a particle of difference if the coefficient of friction of the babbitt is lower, for in a well-lubricated bearing, the metal surfaces do not touch. Therefore, the friction of the bearing will depend on the coefficient of friction of the lubricant. Friction being the direct cause of heat, a bearing will heat either on account of an insufficient supply of oil, or due to the oil not having enough body to withstand the load.

An oil-groove on each side of the crank brasses will form two pockets and there is no danger of the oil being squeezed out.

With this method of fitting brasses, there is no need of other oil grooves in either of the brasses to aid in distributing the oil, as the motion of the crankpin distributes the oil far more effectively.

Samuel L. Robinson.

Vera Cruz, Mex.

It seems to me that those brasses were not properly fitted to the pin or that the engine was out of line, otherwise there should have been no trouble. It is my experience with this metal for bearings that if the brasses fit correctly and the parts are in line, one can get along well with them. We have always thought they were more likely to heat than babbitt. A babbitt bearing has a tendency to form itself to fit the journal, especially if the pressure is heavy or it warms up somewhat.

The one serious fault with the brass bearing is that, if it gets hot, it generally damages the journal. Cast iron is an ideal bearing metal if kept properly lubricated.

A case-hardened journal works well with brass bearings; if kept well oiled, there is but little wear or trouble. We have a gas engine, which has a 6-in. diameter, case-hardened and ground wristpin, which gives entire satisfaction with brass boxes. This engine once wore the pin (not case hardened) and brasses about $\frac{1}{16}$ in. per 10-hr. run on as nice a pin as ever went into an engine. Another gas engine, with overhung cranks and brass boxes, used to get hot, which often was not the fault of the bearing metal. Sometimes the pins would get loose in the cranks, and at other times the oil would fail. As we visited it only about once an hour it had time to get as hot as it felt like. When we found it smoking, we would feed water through the oil piping until it had cooled somewhat. We would then feed in a quart of oil and sapolio, put the oil cup on, set the feed lively, and let it go at that. Incidentally, I do not believe in putting sapolio or anything of that nature in a good bearing. About the best lubricant I have ever used for a "bad actor" is cylinder oil and white lead mixed together.

Why do the valve-gear bearings on a steam pump wear so rapidly? Some say the oiling is neglected. Now, I have made it a point to see that the gear was well oiled, but the wear went on just the same. Possibly, the bearing pressure was too great.

We operate an air compressor that sometimes develops a knock in the cylinder. It is a single-stage machine compressing to 80 lb. The knock is caused by carbon baking on the unjacketed heads, especially the upper part, where the discharge valves are, thereby filling the clearance space.

J. O. Benefiel.

Anderson, Ind.

I have used solid brass boxes on small pins up to 3½ in. in diameter where the rod was of the marine type, but in every case the pin was badly cut. I am opposed to brass boxes for crankpins, because they produce greater friction. If the oil supply should fail, the pin and boxes may be badly cut, while with babbitt lining the babbitt will melt out without doing any serious damage to the pin. In this case, I believe that in time the brass boxes could have been made to run with some degree of success, but the babbitt-lined boxes gave so much better results that there was no reason to change.

Once I used brass boxes on the crankpin of an air compressor in preference to babbitt for the sole reason that the compressor was in an isolated part of the mill, and frequently the oil cups would run empty (it was oiled by the millwright's helper, who was sometimes busy on other work and forgot it), in which case it would get hot, grip the pin and throw out the circuit-breaker. With babbitted boxes it was usually necessary to put in a set of new ones as the babbitt would be melted out; with brass it was necessary only to cool them off and put on some oil. Later, grease was substituted for oil, which prevented further trouble.

J. C. Hawkins.

Hyattsville, Md.

I am using bronze boxes on the crankpin and on the wristpin end of the rod on an oil engine of the trunk-piston type. The crank boxes are marine, the piston end is a solid stub with a wedge and bolt, and is open to admit of adjustment, but the crank boxes are brass

to brass. These boxes have been in service six years, and have been taken apart three times only, to examine the piston rings. We have never dressed off either one and there is no knocking.

J. P. COLTON.

Ohio City, Ohio.

Human Element in Coal Sampling

I was much interested in the editorial on coal sampling in the July 21 issue. As to the relative merits of intelligent and ignorant men as coal samplers, both classes have their weaknesses. The intelligent man, especially if he is to be affected by the outcome of an analysis, either financially or otherwise, is likely to give way to his prejudices; on the other hand, the ignorant laborer is likely to possess a little knowledge, which, according to the adage, is a dangerous thing.

A few weeks ago I collected a coal sample for analysis and the crushing in the preparation of the sample was intrusted to an Italian laborer. Upon returning a half hour later I was surprised to find that the laborer had carefully picked out and laid aside a number of large pieces of slate. When asked his reason for doing this, he said: "Slate no good; no burn." I have observed this same tendency in laborers employed as coal samplers several times. They are likely to come to the conclusion that coal which the boss needs for some special purpose should be carefully selected, and that slate and bone, being worthless, should be rejected.

In taking or preparing a sample of coal for analysis, I would prefer to intrust the work to a man who understands its purpose, after instructing him in the importance of taking the sample entirely without prejudice. This work is just as important as the analysis itself and deserves intelligent attention, coupled with strict honesty.

"Business honesty," as one of POWER'S recent editorials calls it, applies as much to the boiler room and the laboratory as to the policy of a manufacturer or grocer. The power plant is buying heat in the form of coal, and selling or using power, and the owner or engineer should feel it his duty not only to get that for which he pays, but also to pay for that which he gets. The coal weights, the sampling and the analysis are all parts of the "scale" which weighs his purchases, and this "scale" should carry no false weights. Honest quality in fuel is just as important to the power-plant man as are pure food, pure clothes, etc., to the general public.

WILLIAM A. DUNKLEY.

Atlantic City, N. J.

Smoke Abatement vs. Economy

Just how great, if any, is the loss due to smoke from boiler furnace stacks? This question as related to the rating under which the boilers are operating when smoky has been too much neglected.

Consider a plant in a locality unprovided with a smoke ordinance and without smoke-consuming devices. In this plant it is desirable to have some smoke at all times rather than to operate with a possible large excess of air. The waste and loss through maintaining the stack clear would undoubtedly be greater than that due to a slight amount of smoke. This particularly holds good in the consumption of liquid fuel.

I have referred to conditions approximating rated boiler capacity. When the reverse is true and the boiler plant is called upon to operate under heavy loads, it has been found impossible to maintain clear stacks, with freedom from smoke, unless the boilers are equipped with smoke-consuming devices. I have found that a higher efficiency can be had by allowing the furnaces to smoke considerably under heavy overload conditions. As the heating surfaces become fouled, the efficiency will drop; then the dusting hose should be used freely on the boilers after they have been operated at very high ratings.

Designers are prone to limit the area and height of stacks too much. After the plant has been completed and put into operation, it is too often found impossible to obtain the draft required to operate the boilers at high ratings without much smoke. Can it be that the designers are afraid the firemen will maintain too high a draft and that the economy will suffer through their ignorance?

If the designers will convince owners of steam plants that it may be profitable to build stacks of sufficient capacity to take care of any condition which may arise, and that it is economy to employ technical men to watch the operation and prevent waste, there would in all probability be much less smoke.

The engineer in charge is usually a man who has served his time in the boiler room as a fireman or water-tender many years since, in the days when economical operation of boilers was not given much consideration.

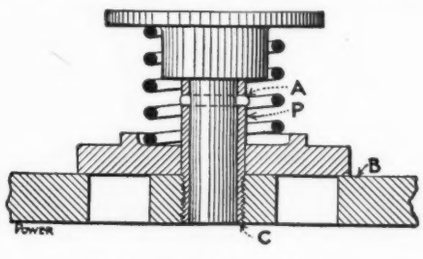
WILLIAM PLAISTED.

Redondo Beach, Calif.

[Many combustion engineers complain because they so frequently find chimneys and stacks too large for the load condition. Also, it seems to be the opinion of most combustion engineers that they would rather coach for the position of head fireman a man who is not, strictly speaking, a technical man.—EDITOR.]

Pump-Valve Stems Repaired

When several valve studs worked loose, their threads and those in the valve plate were spoiled. A quick-repair job was done by pressing the stems into one-half



REPAIRED VALVE STEM

inch pipe nipples *P* and pinning through both stem and pipe at *A*. The pressure plate *B* was then tapped out to one-half inch pipe size at *C*. This has given better satisfaction than the original, partly on account of the larger size of the stem.

EARL PAGETT.

Coffeyville, Kan.

Inquiries of General Interest

Dimensions of Tapered Pin—If a tapered pin which is to be finished 4 in. in diameter at the large end, is to taper 1 in. to the foot and when finished is to be 12 in. long what will be the diameter of the small end of the pin when finished?

E. F. T.

The diameter of the small end would be 3 in., for taper is the actual reduction in size, although it is sometimes confused with slope with respect to the axis.

Horsepower Rating of Automobile Engine—What is the formula for the nominal horsepower of automobile engines?

J. E. C.

Their usual nominal horsepower rating is according to the formula

$$\text{hp.} = \frac{d^2 \times n}{2\frac{1}{2}}$$

in which d = diameter of cylinders in inches and n = the number of cylinders.

Strength of Rivets in Double Shear—Why are not rivets in double shear considered to have twice the strength of rivets in single shear?

T. M.

Because tests of riveted joints have generally shown that rivets in double shear do not offer twice the resistance of rivets in single shear, which is probably due to unequal distribution of the stress in the two rivet sections when in double shear.

Horsepower-Hours—If an engine develops an average of 50 hp. during 10 hr. and 25 hp. during 14 hr. per day, what number of horsepower-hours would be developed in 30 days?

J. M.

During ten hours each day the development would be

$$10 \times 50 = 500 \text{ hp.-hr.},$$

and during 14 hr. per day the development would be

$$25 \times 14 = 350 \text{ hp.-hr.};$$

hence for 30 days the development would be:

$$(500 + 350) \times 30 = 25{,}500 \text{ hp.-hr.}$$

Patents—Can a patented article be made by anyone for one's own use? If an article is marked "patent applied for," can it be made for one's own use?

A E. C.

The right to manufacture and use a patented article without liability is limited to experimenting with it only. The intent is to permit research along the same lines and not to grant a privilege without a just compensation. An article for which a patent has been applied, when so designated, is entitled to the same consideration.

Water Heated by Given Quantity of Steam—One thousand pounds of steam at 212 deg. F. is used for heating a building and the condensation is returned to the boiler at 192 deg. F. If the heat given off is applied to raising the temperature of water, how many pounds of water would it raise from 32 deg. to 112 deg. F.?

E. G.

Each pound of steam delivered at 212 deg. F. would contain 1150.4 B.t.u. above 32 deg. F., and as each pound of condensate when returned to the boiler at 192 deg. F. would contain 192 — 32 = 160 B.t.u., the heat transferred to the building per pound of steam used at 212 deg. F., and converted into condensate at 192 deg. F. would be 1150.4 — 160 = 990.4 B.t.u.; or for 1000 lb. would amount to

$$1000 \times 990.4 = 990{,}400 \text{ B.t.u.}$$

To raise 1 lb. of water from 32 deg. F. to 112 deg. F. requires 79.93 B.t.u., and, therefore, the 990,400 B.t.u. used for heating the building would be capable of raising

$$\frac{990{,}400}{79.93} \text{ or } 12{,}390 \text{ lb. of water}$$

Plunger Pumps in Series—How much pressure could be pumped against by two plunger pumps each of the same size of steam ends and plungers and each capable of pumping against a pressure of 160 lb., if arranged in series, i.e., with the delivery of one of the pumps connected with the suction of the other?

T. J. C.

Assuming that the pumps are double acting with the plungers on opposite ends connected together and neglecting loss of pressure by friction in the passage of the water from one pump to the cylinder of the other, a plunger of the second pump during its suction stroke would be acted upon by 160 lb. pressure which would be transmitted to the plunger making a discharge stroke. The assistance so rendered would be as much as the pressure exerted by the steam and the pump would be able to work against a pressure of

$$2 \times 160 = 320 \text{ lb. per sq.in.}$$

In case, however, the second pump were a single-acting plunger pump, there would be no such advantage, for although the first pump delivered the water under pressure to the second one, the second one would be employed in maintaining the pressure without capacity or assistance to increase the pressure above 160 lb.

Diameter of Uptake—What diameter of smoke uptake would be equal to the combined areas of tubes of one return-tubular boiler having ninety 2½-in. tubes and another having one hundred 3-in. tubes?

B. V.

The internal diameter of a standard 2½-in. boiler tube is 2.282 in., and its cross-sectional area is

$$2.282 \times 2.282 \times 0.7854 = 4.09 \text{ sq.in.},$$

and 90 tubes would have a cross-sectional area of

$$4.09 \times 90 = 368.1 \text{ sq.in.}$$

A standard 3-in. tube has an internal diameter of 2.782 in. and a cross-sectional area of

$$2.782 \times 2.782 \times 0.7854 = 6.079 \text{ sq.in.},$$

and 100 tubes would have a total cross-sectional area of

$$6.079 \times 100 = 607.9 \text{ sq.in.}$$

The united area of tubes of both boilers, therefore, would be

$$368.1 + 607.9 = 976 \text{ sq.in.}$$

An uptake pipe of the same cross-sectional area would have a diameter of

$$\sqrt{\frac{976}{0.7854}} = 35.2,$$

or practically 36 in. diameter.

Steam from a Cubic Inch of Water—What would be the pressure of a cubic foot of dry saturated steam made by the complete evaporation of a cubic inch of water from 60 deg. F.?

D. L.

At 60 deg. F. water weighs 62.37 lb. per cu.ft., hence the steam generated from a cubic inch of water would weigh

$$\frac{62.37}{1728}$$

or about 0.0361 lb. Referring to Marks and Davis steam tables giving the density of steam at various pressures, it will be seen that the weight of 0.0361 lb. per cubic foot comes between 0.03597, which is the density or weight per cubic foot of steam at 14.13 lb. per sq.in. absolute pressure, and 0.03664, the density at 14.41 lb. absolute. The given weight per cubic foot would, therefore, be

$$0.0361 - 0.03597 = 0.00013 \text{ lb.}$$

greater than at 14.13 lb. absolute. As with an increase of pressure from 14.13 to 14.41 lb. absolute, the density increases at the rate of

$$\frac{0.03664 - 0.03597}{14.41 - 14.13}$$

or 0.00239 lb. per pound increase in pressure, than when the density became equal to 0.0361 lb. per cu.ft. the pressure for that density would be found by interpolation to be

$$14.13 + \frac{0.0361 - 0.03597}{0.00239} = 14.18 \text{ lb. absolute.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XXII

LAST LESSON'S ANSWERS

96. As 1 gal. of water weighs about $8\frac{1}{3}$ lb., the total mass of water raised is

$$1000 \times 8\tfrac{1}{3} = 8333\tfrac{1}{3}\ lb.$$

Since this amount of water is lifted 120 ft. in one minute, the work done equals

$$8333\tfrac{1}{3} \times 120 = 1{,}000{,}000\ ft.\text{-}lb.$$

and the horsepower required to do this work is

$$\frac{1{,}000{,}000}{33{,}000} = 30.3\ hp.$$

97. The work done in the water end of the pump is equal to 30.3 hp. If the efficiency between the steam and water ends is 70 per cent., then the horsepower required in the steam end is

$$30.3 \div 0.70 = 43.3\ hp.$$

98. Twenty tons of coal equals

$$2000 \times 20 = 40{,}000\ lb.$$

The vertical distance the coal is raised is 150 ft. From equation (52)

$$Hp. = \frac{F \times S}{T \times 33{,}000}$$

In this problem $F = 40{,}000$ lb., $S = 150$ ft. and $T = 60$ min., hence the horsepower required is

$$\frac{40{,}000 \times 150}{60 \times 33{,}000} = 3\tfrac{1}{3}\ hp.$$

This answer holds true on the assumption that the engine is hoisting continuously for the entire hour. As an actual fact, such is not the case, as allowance must be made for the loading and lowering of the bucket, so that the actual time of hoisting is considerably less than one hour, and hence the horsepower required will depend upon the rate at which the bucket is being raised in feet per minute.

99. Potential energy is weight times vertical distance above a given reference plane. Here the weight is 1000 lb. and the distance is 95 ft., hence the potential energy is

$$95 \times 1000 = 95{,}000\ ft.\text{-}lb.$$

100. The kinetic energy of the body is $\frac{W\ V^2}{2\ g}$. To determine this energy it is necessary to find the velocity V which the body has after it has fallen the vertical distance of 95 ft. This may be found from equation (43), where $V^2 = 2\ gH$, or

$$V = \sqrt{2\ g\ H} = \sqrt{2 \times 32.16 \times 95} = \sqrt{6102} = 78.2\ ft.\ per\ sec.$$

Substituting this value of V in the equation for kinetic energy there results

$$Ke = \frac{W\ V^2}{2\ g} = \frac{1000 \times 78.2 \times 78.2}{2 \times 32.16} = 95{,}000\ ft.\ lb.$$

ENERGY (*continued*)

Problems 99 and 100 illustrate the fact that potential energy may be changed into kinetic energy by allowing the object to fall through the vertical distance above the given reference plane, or, as commonly expressed, by converting "head into velocity." This may be shown more clearly by comparison of the equations for potential and kinetic energy. Thus

$$K = WH$$

$$\text{and } Ke = \frac{W\ V^2}{2\ g}.$$

From equation (43)

$$V^2 = 2\ gH$$

$$\text{or } H = \frac{V^2}{2\ g}.$$

Substituting this value in the equation

$$Ke = \frac{W\ V^2}{2\ g},$$

there results $Ke = WH$

which is the same as the expression for potential energy.

Moreover, *the total amount of energy in the body remains constant and is equal to the sum of the kinetic and potential energies.* In problem 100, had the body fallen only 47½ ft. its total energy would still have been 95,000 ft.-lb.; only 47,250 ft.-lb. would have been kinetic and 47,250 would have been potential energy.

Equation (57) shows that energy may be converted into useful work, and *vice versa;* but in no case is it possible to destroy or annihilate energy. This gives rise to the law commonly called the *"Conservation of Energy,"* which may be summed up in the following three statements:

(1) *The sum total of the energy in the universe remains constant.*

(2) *Energy may be converted from one form to another.*

(3) *Energy cannot be destroyed or annihilated.*

The first statement may not be evident at first sight. In a steam engine, due to improper lubrication, unlagged cylinders and poor materials, the efficiency may run very low and the engineer will say there is a loss of power. This statement is true as far as the performance of useful work is concerned, but there is no loss of energy. The steam by virtue of the energy it possesses does several things in the engine cylinder; first, it must overcome all frictional losses; second, it must heat up the cylinder, and, last of all, it must overcome the external resistance or load on the engine. Hence the energy in the steam is all accounted for and there is no loss, but simply a conversion of one form of energy into several other forms. Whatever energy may be lost in one form is sure to appear in a different form, so that the sum total of the energy of the universe remains constant.

That part of the energy of the steam which is not converted into useful work is called *"dissipated energy."*

The second part of the law has already been referred to, that it is possible to change energy from one form to another. This change is universal and is taking place continuously. The human being eats food to provide

him with muscular energy which enables him to cultivate his fields and produce more food, which in turn is converted into muscular energy, and so the process continues. The ambition of the modern power plant engineer is to convert the heat energy resident in coal into electrical energy with as little loss as possible. Thus far his efforts have resulted in converting about 18 per cent. of the heat energy in the coal into the electrical form of energy. The introduction of the internal combustion engine is destined to raise this figure to a much higher value.

The third part of the law states that energy can never be lost. This is best illustrated by considering the action of the sun—the main source of the earth's energy. In the early ages the sun supplied the energy to plant life, which gradually developed into trees and into great forests. These in time perished and were buried deep in the earth, and after many years appeared in the form of coal, the energy of which may be liberated by combustion. Part of the coal's energy is transformed into work and the remainder is dissipated in various forms, but none of it is ever lost.

The sun by virtue of the energy it possesses raises the water from the level of the sea to the highest mountains, and as the water flows down from these elevations it becomes possible to convert its potential energy into kinetic energy, which may be utilized to operate waterwheels and turbines.

Heat

Perhaps the most common form of energy is that known as *heat,* to which reference has already been made. For many years scientists were puzzled as to the form and nature of heat. Some considered it as a substance that had weight; but it remained for the simple experiment of rubbing two pieces of ice together to prove that heat is simply a form of molecular energy. As the molecules of the body move faster and faster, their kinetic energy becomes greater, and the sum total of all their energies constitutes what is known as heat.

The commonly accepted unit of heat is the *British thermal unit,* which is the amount of heat required to raise the temperature of 1 lb. of water 1 deg. Fah., assuming the water to be at its greatest density, which is about 39 deg. F. Recent experiments have proved that the British thermal unit commonly indicated by the letters B.t.u. is equivalent to 780 ft.-lb. of work. A pound of coal contains about 13,000 B.t.u. If all the heat in the coal could be transformed into work there would result $13{,}000 \times 780 = 10{,}140{,}000$ ft.-lb., and if the heat was liberated in one minute the equivalent horsepower would be

$$\frac{10{,}140{,}000}{33{,}000} = 307.$$

Example—Under certain conditions it takes 1050 B.t.u. to convert one pound of water into dry steam. If all the heat in the pound of coal could be transferred to the water, how many pounds would be evaporated for every pound of coal burned? The number of pounds of water evaporated per pound of coal will equal $\frac{13{,}000}{1050}$ or 12.4. In actual practice, only about 80 per cent. of this figure is realized. One horsepower is equivalent to 33,000 ft.-lb. per min., which expressed in B.t.u. equals $\frac{33{,}000}{780}$ or 42.3.

The figure 780 is called the mechanical equivalent of heat since it expresses the relation between the units of different forms of energy.

If one pound of coal were burned in one minute the horsepower equivalent to the heat energy in the fuel would be $\frac{13{,}000}{42.3} = 307$, or if the coal was burned in one hour the horsepower equivalent would be $\frac{307}{60}$ or about 5. A boiler horsepower is equivalent to about 13 engine horsepower, so that the burning of one pound of coal per hour is capable of producing about $^5/_{13}$ boiler horsepower. Hence, to secure one boiler horsepower it is necessary to burn $^{13}/_5$ or 2⅗ lb. of coal per hour. This of course is the theoretical value. Under average conditions one boiler horsepower will be secured by the combustion of 3½ to 4 lb. of coal per hour.

Study Questions

101. What three quantities determine the amount or quantity of heat in a given mass of material?

102. Explain the meaning of the term 1 deg. F.

103. Does the amount of heat required to change the temperature of water 1 deg. F. remain constant as the temperature of the water increases?

104. A certain coal averages about 12,000 B.t.u. to the pound. Find the horsepower equivalent to the combustion of 1000 lb. of coal per hour, assuming all the heat energy in the coal to be liberated during combustion.

What would be the equivalent boiler horsepower, assuming that 13 engine horsepower equal one boiler horsepower?

Note—A boiler horsepower is the evaporation of 34½ lb. of water per hour into dry steam at 212 deg. F. from a feed-water temperature of 212 deg. F. To evaporate 1 lb. under these conditions it requires 970.4 B.t.u. The heat equivalent of a boiler horsepower is equal to

$$34\tfrac{1}{2} \times 970.4 = 33{,}479 \textit{ B.t.u. per hr.,}$$

or 558 B.t.u. per min. An engine horsepower is equal to 42.3 B.t.u. Therefore the boiler horsepower is equal to $\frac{558}{42.3}$ or 13 engine horsepower, approximately. As the efficiency between switchboard and coal pile is about 6 per cent., it is to be noted that one boiler horsepower under working conditions produces just about one engine horsepower.

105. In problem 104, if it takes 1050 B.t.u. to evaporate one pound of water, how many pounds would be evaporated under the given conditions, assuming that 80 per cent. of the heat in the fuel is transferred to the water in the boiler?

More Magic Compound Fakers—There has recently been put upon the market in Germany quite a flood of preparations for the purpose of making a brew in which coal or coke is to be wetted before being put upon the fire. The alleged result of using these preparations is that the coal burns more readily and that there is a great saving in the amount of fuel required. Herr T. Oryno, of the laboratory of the Berlin Fermentation Institute, has analyzed a number of these preparations and found them to consist of various salts such as sulphate of magnesia, sulphate of soda, common salt, nitrate of soda, and so on generally with a small proportion of oxide of iron. He concludes that they cannot have the effects attributed to them.—"The Engineer."

GROUP AT THE CONVENTION OF THE UNIVERSAL CRAFTSMEN

Craftsmen's Convention

The twelfth annual convention of the Universal Craftsmen Council of Engineers was held at Cleveland, Ohio, August 4 to 8, with headquarters at the Hollenden Hotel. There were upward of 200 delegates in attendance, representing more than 300 votes.

The meetings of the delegates were held in the large assembly hall of the hotel and the several committee rooms were conveniently located. On the same floor four large parlors were neatly fitted up for the exhibit of engineers' equipment and supplies. The display occupied sixty booths, which were well attended during the five days.

On Tuesday morning at 11 o'clock the opening exercises of the convention took place, William H. Kennedy, presiding. After the invocation by P. H. Early, grand chaplain, the chairman introduced Frederick Sidlo, Director of Public Service, representing Mayor Baker, who cordially welcomed the convention to the city of Cleveland. Grand Chief Henry C. Senn responded for the engineers. Homer G. Powell spoke interestingly on fraternity, and was followed by Walter S. Cadwell, past grand chief. "The Old Guard" was the subject allotted to Past Grand Chief Robert G. Ingleson, who made a short and pleasing address. An impressive part of the services occurred here when Herbert E. Terry, grand warden, asked the privilege of the floor, and on behalf of the Toronto and Winnipeg councils of Canada presented the grand body a silk English flag. John Cope feelingly accepted the gift and the American and English flags were joined together with a white silk bow.

The meeting then went into executive session, the necessary committees were appointed, and an adjournment was taken until the afternoon business session.

There was a liberal program of entertainment in every event of which the ladies were included, such as theater parties, automobile trips to Luna Park, Euclid Beach Park and through the park system of the city.

On Wednesday evening an enjoyable entertainment was given in Assembly Hall, comprising the following numbers: Miss Doris Siegrist, of Cleveland; H. R. Wunder, of Cincinnati; E. C. Adams, Anchor Packing Co.; Billy Murray and Joe McKenna, of Jenkins Bros.; George E. Andrews and Jack Armour, of "Power."

On Thursday evening there was a moonlight sail on Lake Erie.

On Friday evening a banquet was held at which 300 covers were laid. At the close of the service the toastmaster, Robert G. Ingleson, introduced Henry C. Senn, who gave a short address, followed by Frank Martin, of Jenkin Bros. Fifteen minutes of entertainment was given by Jack Armour.

At the closing session of the delegates the following grand officers were elected for the ensuing year: Henry C. Senn, past chief; William Armstrong, chief; Charles F. Siegrist, assistant worthy chief; Nathan J. Burdick, secretary; Herbert E. Terry, treasurer; Frank M. Townsend, warden; Samuel J. Hunt, guard; P. H. Early, chaplain; O. N. Pomeroy, historian; Frank Conroyd, John Moore and Andrew Bennett, trustees. Immediately preceding the election of officers the annual memorial services were held.

Rochester, N. Y. was selected as the next convention city, in August 1915.

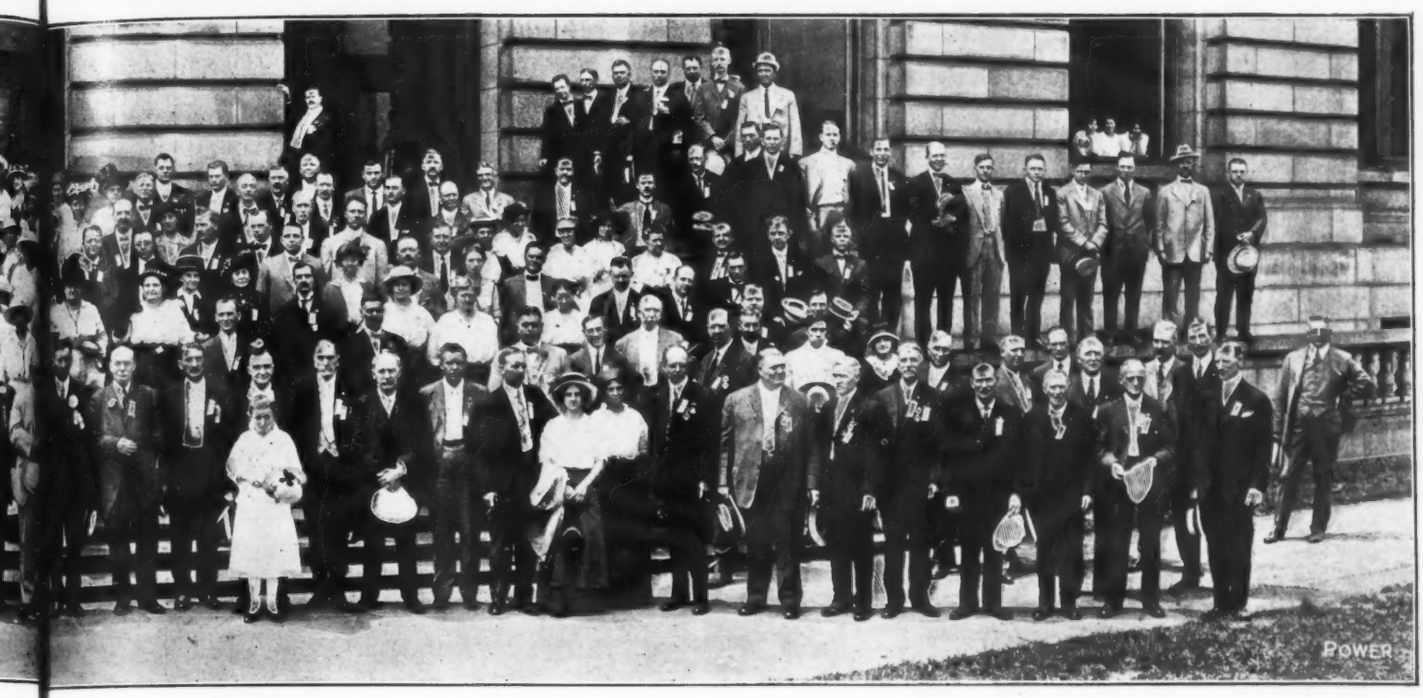
THE EXHIBITORS

American Steel & Wire Co.	McDonough Regulator Co.
Bishop, Babcock & Becker Co.	McLeod & Henry Co.
Buckeye Chemical Co.	Otis Elevator Co.
C. E. Squires Co.	Peerless Rubber Mfg. Co.
Cleveland Feed Water Regulator Co.	"Power"
Cleveland Mfg. & Supply Co.	Quaker City Rubber Co.
Consumers Rubber Co.	R. J. Bissett Co.
Crandall Packing Co.	Skinner Engine Co.
Dearborn Chemical Works,	Standard Oil Co.
Diamond Power Specialty Co.	Standard Waste & Mfg. Co.
Engineers' Appliance Co.	Strong, Carlisle & Hammond Co.
Federal Graphite Mills	The Harmon Feed Water Power Specialty Co.
Garlock Packing Co.	The Lunkenheimer Co.
Goodyear Tire & Rubber Co.	The Thompson. Hayes Co.
Greene, Tweed & Co.	The V. D. Anderson Co.
Griscom-Russell Co.	The Universal Lubricating Co.
Hawkeye Boiler Compound Co.	The William Powell Co.
Hill, Hubbell & Co.	Tomlinson Steam Specialty Co.
Ingersoll-Rand Co.	Trill Indicator Co.
Jenkins Bros.	Union Iron Works
John A. Roebling Sons' Co.	William Patterson Supply Co.
Keystone Lubricating Co.	Yarnall, Waring Co.
Lagonda Manufacturing Co.	
Liberty Manufacturing Co.	

Addendum to the Description of the Dime Savings Bank Building Plant

The table of the principal equipment in the plant of the Dime Savings Bank Building, Detroit, Mich., accidentally omitted from the article as it appeared in the last issue, is printed on the next page.

Canadian Water Power Exhibit—At the Panama-Pacific Exposition in San Francisco next year an interesting exhibit in the Canadian building will include a series of models of typical water power plants from the Atlantic to the Pacific. These will be arranged in a semicircle in front of a painting 75 feet long by 9 feet high, presenting a birdseye view of the whole Dominion, with all the known water powers indicated, whether developed or not.



COUNCIL OF ENGINEERS, CLEVELAND, O., AUGUST 4 TO 8

PRINCIPAL EQUIPMENT OF DIME SAVINGS BANK BUILDING PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Stirling type S special	350 hp	Generate steam	150 lb. pressure, no superheat	Babcock & Wilcox Co.
4	Stokers	Taylor, three-retort		Boiler furnace	Mechanically operated	American Engineering Co.
1	Traveling bucket	Monorail	900 lb.	Coal from bunker to boiler	Motor driven, Howe suspended scale	Yale & Towne Mfg. Co.
1	Fan	"Sirocco"	No. 8	Forced draft to stokers	Engine-driven, capacity 3600 cu.ft. per min.	American Blower Co.
1	Fan	Steel plate	40x28-in.	Forced draft to stokers	Motor-driven, capacity 3600 cu.ft. per min.	B. F. Sturtevant Co.
1	Engine	Simple vertical	7x8-in.	Drive forced draft fan	230 volt, 150 lb. pressure, 600 r.p.m.	B. F. Sturtevant Co.
1	Motor	Variable speed	60 hp.	Drive forced draft fan		Crocker-Wheeler Co.
2	Meters	Venturi	4x1-in. tube, 2x½-in. tube	Boiler feed and Holly loop		Builders Iron Foundry
1	Heater	Open	1500 hp.	Heat boiler feed	Exhaust or live steam	Warren Webster & Co.
3	Heaters	Closed	Each 1400 gal. per hr.	Hot water	Exhaust or live steam	Warren Webster & Co.
2	Pumps	Duplex	7½x5x10-in.	Boiler feed	150 lb. pressure, 50 ft. per min.	The Blake & Knowles Steam Pump Works
2	Injectors	U. S.	2-in.	Boiler feed	150 lb. pressure, lift 310 ft.	American Injector Co.
1	Pump	Triplex	5½x8-in.	House pump	Motor driven, 45 r.p.m.	The Deming Co.
1	Pump	Centrifugal, four-stage	2-in.	House pump	Motor-driven, 1100 r.p.m.	Kerr Turbine Co.
2	Motors	Direct current	15 hp. and 20 hp.	Drive house pumps	230-volt, 1100 r.p.m.	Crocker-Wheeler Co.
2	Pumps	Simplex	10x16x16-in.	Vacuum heating system	40 ft. per min.	Warren Webster & Co.
2	Pumps	Centrifugal	4 in.	Sump	Motor driven, 1100 r.p.m.	Yeomans Bros.
1	Refrigerating system	Absorption	30 ton	Restaurant and drinking water	Exhaust steam	Carbondale Machine Co.
2	Pumps	Burnham simplex	6½x4x8-in.	Drinking water	150 lb. pressure, 50 ft. per min.	Union Steam Pump Co.
2	Pumps	Burnham simplex	10x6½x12-in.	Brine	150 lb. pressure, 50 ft. per min.	Union Steam Pump Co.
1	Pump	Burnham simplex	8x3½x12-in.	Aqua	150 lb. pressure, 50 ft. per min.	Union Steam Pump Co.
1	Pump	Duplex	12x6½x12-in.	Hydraulic money lift and passenger elevator	150 lb. pressure, 50 ft. per min.	The Blake & Knowles Steam Pump Works
2	Water filters	Double filters	8x8 ft.	Purify house-service water		Wm. B. Scaife & Sons Co.
5	Engines	Four-valve	17x27-in.	Main units	150 lb. pressure, 150 r.p.m.	Ball Engine Co.
5	Generators	Direct current	200 kw.	Main units	115-230 volt, 150 r.p.m.	Crocker-Wheeler Co.
5	Lubricators	Force feed	2 feed	Lubricate engine cylinders	2 strokes per min.	Hills-McCanna Co.
2	Filters	Oil	50 gal.	Filter spent oil		Richardson-Phenix Co.
9	Motors	Direct traction	Eight 25 hp., one 30 hp.	Elevators	230 volts, 63 r.p.m. max., car speed 550 ft. per min.	Otis Elevator Co.
5	Fans	"Sirocco"	Nos. 6, 7, 8 and 9, one 42-in. Venturi	Fresh air	Motor-driven, 213 to 320 r.p.m.	American Blower Co.
5	Motors	Direct-current	Total 40 hp.	Drive fresh air fans	220-volt, 213 to 320 r.p.m.	Crocker-Wheeler Co.
4	Exhausters	"Sirocco"	Nos. 4, 5 and 6	Exhaust air	Motor-driven	American Blower Co.
4	Motors	Direct-current	Total 22 hp.	Drive exhaust fans	220-volt, 260 to 400 r.p.m.	Crocker-Wheeler Co.
2	Air washers	No. 1	No. 1	Restaurant and bank		Warren Webster & Co.
1	Vacuum cleaner	Rotary valve	4 sweepers	Building service	Motor driven, 350 r.p.m.	American Rotary Valve Co.
1	Motor	Direct-current	15 hp.	Drive vacuum cleaner	230-volt, 800 r.p.m.	Crocker-Wheeler Co.
2	Air compress'rs	Vertical	6x4½ in.	Compressed air service	Motor-driven, 500 r.p.m.	Gardner Governor Co.
2	Motors	Direct-current	3 hp.	Drive air compressors	230-volt, 1100 r.p.m.	Crocker-Wheeler Co.
1	Water weigher	Balancing type	20,000 lb. per hr.	Returns from heating system		Willcox Engineering Co.

Canadian Association's Twenty-Fifth Annual Convention

The twenty-fifth annual convention of the Canadian Association of Stationary Engineers was held at Ottawa, Ont., on July 28, 29 and 30. There was a large increase in the number of delegates in attendance over the past few years. The meetings were held in the board room of the Ottawa Amateur Athletic Association Building, and the spacious gymnasium adjoining was conveniently and tastefully arranged for the display of power-plant equipment, under the auspices of the Canadian Supplymen's Association.

The opening exercises of the convention took place at two o'clock on Tuesday afternoon. Executive President Samuel E. Cosford, presiding. After a short address by the president, Executive Secretary August Kastella introduced Mayor McVeity, who cordially welcomed the delegates and their friends to Ottawa. He pointed out the beauties and advantages of the city and warmly invited the company to come again. John E. Robertson, past executive president, responded for the engineers, and Ernest A. Wilkinson, president of the Supplymen's Association spoke for the exhibitors. The delegates then went into executive session and after the appointment of the necessary committees the meeting was adjourned until three o'clock.

At the several business sessions important matters of general interest to the engineers were discussed and passed upon. The reading of the treasurer's report showed the organization to be in a sound financial condition. An important measure was passed by the deelgates in the appointing of a committee to confer with the government board to request the adoption of graded certificates of license, the Government to decide as to the ability of the engineer. At present there is but one certificate issued.

The Ladies Auxiliary met in executive session, and had a successful meeting and new names were added to the list of membership.

The entertainment program included automobile drives throughout the city for the ladies and visits to the Government mint, Rockliffe Park and the residence of the Governor-General of Canada.

On Wednesday afternoon there was a boat ride to Belle Isle Park by invitation of the Supplymen. There was a good program of outdoor sports of all kinds, with prizes for each event. The baseball game between the Engineers and the Supplymen was won by the latter by the score of 11 to 7. A good band of music was in attendance and refreshments were served.

On Tuesday evening a banquet was given by Capital City Lodge at the Russell Hotel, at which 200 covers were laid. After partaking of an appetizing dinner August Kastella, the toastmaster, introduced the following speakers: Mayor McVeity, Comptroller McLean, ex-Mayor Hopewell, Charles Heitzman, A. M. Wickens, M. R. Griffiths, A. C. Pulver, E. A. Wilkinson, George G. Lee, Samuel Cosford, William Merrill, Henry Thompson, Alexander Campbell and B. L. Thompson. An enjoyable entertainment was furnished by Earl F. Heatherington, James E. Fiddes, Foley and Neville and Jack Armour.

At the final meeting of the delegates the following executive officers were elected: Samuel E. Cosford, of Hamilton, past president; Alfred W. Heath, of Hamilton, president; Robert Dyson, of Guelph, vice-president; John Hale, of Hamilton, secretary; William E. Archer, of Toronto, treasurer; William G. Forbes, of Montreal, conductor; Ernest Horan, Owen Sound, doorkeeper. The officers were installed by Past President John E. Robertson. August Kastella, of the Ottawa Association, was the recipient of a past president's jewel. A vote of thanks was given to the Ottawa Board of Trade and also to the local association for their efforts in making the convention a success.

The Supplymen's Association elected the following officers: A. C. Pulver, president; Herman L. Peiler, first vice-president; C. G. Peterson, second vice-president; J. B. Faatz, assistant secretary; James E. Fiddes, chairman entertainment committee; Lewis H. Hager, charman reception committee; Earl F Heatherington, director of exhibits.

Hamilton, Ont., was selected as the next place of meeting in July 1915.

EXHIBITORS

The Dart Union Co.
The Goldie & McCulloch Co.
"The Canadian Manufacturer"
Peerless Rubber Manufacturing Co.
Imperial Oil Co., Ltd.
The H. W. Johns-Manville Co.
Anchor Packing Co.
E. Leonard & Sons
Canadian Allis-Chalmers Co.
Perolin Co. of Canada, Ltd.
McHaughton Grate Bar Co.
Boiler Repair & Grate Bar Co.
Standard Sanitary Manufacturing Co., Ltd.
The James Morrison Brass Manufacturing Co., Ltd.
Jenkins Bros.
Joseph Dixon Crucible Co.
"The Power House"
"Power"
Quaker City Rubber Co.
Canadian Griscom-Russell Co
Cling-Surface Co.
Dearborn Chemical Co.
The Lunkenheimer Co.
H. L. Peiler & Co.
Garlock Packing Co.

AT THE CANADIAN ASSOCIATION OF STATIONARY ENGINEERS' CONVENTION, OTTAWA, JULY 28-30

Recent Court Decisions

Digested by A. L. H. STREET

Injury Caused by Backfire of Gas Engine—Liability for injury to the engineer of a stationary gas engine, caused by backfiring through an open intake pipe in front of which he was standing, was sustained by the Wisconsin Supreme Court in the late case of Jahn vs. Northwestern Lithographing Co., 146 "Northwestern Reporter," 1131. In affirming judgment in favor of plaintiff, the engineer, the court decided that the jury was warranted in finding that the employing company did not provide a safe place of employment, as required by the laws of the state, although the location of the intake pipe on a level with plaintiff's face was temporary only, while a test of newly installed equipment was being made.

Duty to Insulate Electric Power Wires—An electric power company cannot escape liability for death of a person, resulting from his coming in contact with a high-voltage wire which the company negligently permitted to remain uninsulated, by showing that similar wires carrying similar currents elsewhere were not insulated, or that insulation would be expensive. (Massachusetts Supreme Judicial Court, Philbin vs. Marlborough Electric Co., 105 "Northeastern Reporter," 893.)

State Control of Navigation—It is beyond the power of a state to grant the right to a water power company to control navigation on a navigable stream. In reaching this decision in the case of Long Sault Development Co. vs. Kennedy, 105 "Northeastern Reporter," 849, the New York Court of Appeals said:

As long as the waters are maintained as navigable, they remain public waters of the state; and as long as they remain public waters of the state, the state is bound to retain control over them in the public interest.

In this case the court adjudged to be unconstitutional a law enacted by the New York legislature in 1907, giving the Long Sault Development Co. the right to maintain dams, etc., in the St. Lawrence River in connection with a power project

OBITUARY

EDWIN F. WILLIAMS

Edwin F. Williams died at his home, 263 West Eleventh St., Erie, Pa., on Tuesday morning, July 28. He had been in failing health for several years and the cause of his death was general breakdown. He is survived by Mrs. Evaline Williams and a daughter, Miss Edwina Williams, who resides in New York.

Mr. Williams was born in Ohio of Quaker parentage, the youngest of a family of eight which moved to a new settlement in central Iowa in 1854. In the latter part of the Civil War he served as private in Company B, Forty-eighth Iowa Infantry. Immediately after his discharge he went on a hunting expedition with two army comrades, out on the Sioux River, which was then on the extreme edge of civilization.

On the advice of an old river engineer, he entered a blacksmith's shop as apprentice, preparatory to a strikers' position on a boat. After serving two years at blacksmithing, he took up stationary engineering. Having worked a while in a machine shop in Cincinnati, he secured his first position as engineer in a small sawmill near Mount Sterling, Ky.

EDWIN F. WILLIAMS

He worked for two years in a distillery in Bourbon County, Ky. The next season he took charge of a large engine and battery of boilers in Chambers sawmills, at Muscatine, Iowa. After this he served some time as assistant miller in a water-driven flour mill in Winneshick County, Iowa. In 1870, he went into the government service, commissioned as engineer in charge of the engineering department at the new agency for the Cheyenne and Arapahoe Indians, being then established on the north Canadian river, eighty miles north of Fort Sill, Indian Territory.

A year afterward he went to the mining camp of Central City, Colo., and engaged in running and repairing mill and mine engines and other machinery. He then returned to Iowa and began a course of education in the high school at Boonsboro. Graduating from this school, he entered the State University at Iowa City, paying particular attention to those branches of learning which would aid him in his future engineering work. Running out of funds, he returned to Central City and took up the old work, and at this time he began to invent things, his first work being a friction clutch for mine hoists.

Securing a patent and some financial assistance, he made a trip to Philadelphia and attended the Centennial Exhibition in that city in 1876. Here he first saw Charles T. Porter, for whose wonderful work he had a sincere admiration which never lessened. Not being able to make satisfactory arrangements for the manufacture of the friction clutch, he went to Council Bluffs, Iowa, and there, with the pattern maker at the Council Bluffs Iron Works, he designed a semi-portable hoisting engine, using the Williams clutch for engaging and disengaging the winding drum without stopping the engine. One was built and was a success. The Council Bluffs Iron Works, represented by The Hendrie & Bolthoff Manufacturing Co., of Denver and Central City, Colo., took up the manufacture and sales on a royalty. A large number of these outfits was sold, but, by a technicality, the royalties were not collectible after the first few.

Mr. Williams then took up his real life work, the study and development of the steam engine. After some five years' experience as erecting engineer and expert for Hill, Clark & Co., Boston; the Hartford Engineering Works, Hartford, and the Southwark Foundry & Machine Co., Philadelphia, he designed and had built his first engine, a 7x8-inch automatic cut-off, at the shops of Charles F. Elmes, Chicago, Ill.

During his engagement with the Southwark Foundry & Machine Co., he made a deep study of the effects of inertia in the reciprocating parts of the steam engine, and to verify the results of his calculations he invented and had built at the Crosby Steam Gauge & Valve Manufacturing Co's works, Boston, an instrument which he applied to some Porter-Allen engines, and drew curves representing the inertia force at the various points of the stroke, which substantiated the correctness of his calculations. This he named the inertia instrument, and he wrote a series of articles on the subject which appeared in the "American Machinist" in 1884 and 1885.

Before the completion of his first engine, orders were obtained for two larger ones which were put into regular service in Chicago. The valves of these engines consisted of a main valve driven directly from an eccentric on the crankshaft and a balanced cut-off within it, driven by a shaft governor. The valves had flat faces, and the main valve was balanced by a pressure plate at its back, wholly surrounded by live steam and exhausting within or under the balance plate. After some experience with these valves, much difficulty being experienced in keeping such large pressure plates straight and free from leakage, he decided to change the system, dividing the large pressure plate into two smaller ones, placed one at each end of the steam chest admitting live steam into the intervening space and exhausting out the ends. It constituted in fact a piston valve of rectangular section provided with pressure plates having means for taking up the wear. This valve system proved successful, and trial steam tests showed remarkably good economy even after much use.

The governor consisted of two weight arms, one on each side of the main shaft, to which were attached weights and springs in the usual way and connected to the cut-off eccentric in a manner to lengthen or shorten the period of steam admission by revolving it around the shaft forward or back. Believing the effects of inertia could be utilized to advantage, an "inertia wheel" was mounted on the crankshaft beside the governor on a frictionless roller bearing, links so attaching it to the governor arms that the inertia effect of the wheel, when the engine speed accelerated, would have a tendency to lift the weight arms, shortening the period of steam admission, and when the speed was retarded the tendency was to depress the weight arms, giving the engine more steam.

After many trials with the inertia wheel attached and detached to the weight arms, it was decided to abandon the inertia wheel as the regulation did not appear to be benefited by its use. This experiment was tried in 1886 or 1887.

Mr. Williams here became a firm believer in compound engines and unhesitatingly advocated them. The immediate result was an order from the Chicago Arc Light & Power Co., under the advice of its able engineer, J. A. Dyblie, for two horizontal, tandem compound engines of 500 horsepower each. The order to build them was given to William Tod & Co., Youngstown, Ohio, under Mr. Williams' personal supervision. These engines were entirely successful and were the pioneers of compounding in electrical service in this country.

The Williams' engine business was then taken up by Fairbanks, Morse & Co., Chicago, who built a shop for their manufacture at Beloit, Wis., Mr. Williams being employed as superintendent. A year or so afterwards he gave up this position and accepted an offer from the Lake Erie Engineering Works, of Buffalo, N. Y., and furnished them a new design of vertical compound and triple-expansion engines, the vertical design then coming into favor on account of the limited floor space required.

These engines were equipped with a new system of valves and governor. Four valves were used for each cylinder, the steam and exhaust being on opposite sides of the bore and driven separately. These valves were of the four-post construction, operating under pressure plates. They were originally self-adjusting because of the difficulty experienced in machining them perfectly. The self-adjusting feature was afterwards abandoned and the valves cast in one piece. The governor was of the one-armed gravity balanced type, which Mr. Williams used in all his future work.

A number of engines was turned out, the most noted one perhaps was the one installed at the Intramural power house at the World's Fair, Chicago, in 1893. This engine was a vertical compound, directly connected to an 800-kw. General Electric generator, one of the first ever built.

On July 4, expecting heavy traffic on the road, a 1500-kw. Corliss driven unit was put into service, assisted by a 500-hp. Greene engine belted unit; a 500-hp. McIntosh & Seymour, a 400-kw. tandem Corliss and the Williams 800-kw. vertical unit were to be kept in reserve. When the first heavy pull came on, an accident happened to the 1500-kw. generator, putting it out of service. The Greene and the McIntosh & Seymour were forced to lay down also. The attempt was then made to run the Williams and the tandem 400-kw. Corliss in parallel. The Corliss was soon brought to a standstill and had to be thrown out. To everyone's surprise the Williams vertical took the whole load with perfect ease, carried it the rest of the day, and ran the load exclusively for some weeks following.

After leaving the Lake Erie Company at the close of the World's Fair, Mr. Williams entered into a contract with William Tod & Co., he having charge of the New York office, where the sales were made and the drawings executed.

After having installed some fourteen engines under this arrangement, averaging approximately 800 hp. each. the business boom of 1900 came on and filled the William Tod works with work for the iron industries for long periods in the future, and the building of the Williams engines was discontinued. The association with the William Tod Co. was most pleasant from beginning to end.

Mr. Williams then redesigned his engines, using the old Williams flat valves in the high-pressure cylinders and four gridiron valves operated across the cylinders by a new system of levers on the low-pressure cylinders. The high-pressure valve being operated by the governor and the low-pressure steam and exhaust by separate eccentrics.

It was his belief that a single-valve governor control on the high-pressure cylinder and a fixed cut-off on the low-pressure was advisable on account of its simplicity, and that the economy in the use of steam would not be inferior to engines having independent cut-off on the high-pressure and governor control on the low-pressure cylinder as well as on the high-pressure, as at normal load the same distribution of pressures would be effected by either system, and there could be no rational difference in the economy, other things being equal.

Orders were taken for seven, two being of the single-cylinder type, and they were built in shops where they had no knowledge of the Williams engines. But they were not built satisfactorily and did not turn out well. This was disheartening, and the work was dropped until proper building facilities could be secured. A company was then organized at Quincy, Ill., with Mr. Williams as chief engineer, the business being managed by Thomas Hill and Edward C. Wells. A number of engines were put into successful service, all vertical.

The steam turbine then came on the market and ruined the vertical reciprocating engine sales. This was a great blow to the new Quincy enterprise, and he severed his connection and came East. Robert Wetherell & Co. then built a pair of his vertical compounds for North Beach, L. I., which were very satisfactory.

After completing the drawings for these engines he spent some time on drawings of a new steam turbine for E. H. Ludeman & Co., of New York. The first of these steam turbines is now under construction. His next work was in the capacity of a coworker with P. D. Johnston, of Cold Spring, N. Y., in the working out of a new oil-burning engine.

While at Cold Spring Mr. Williams conceived the idea of an economical high-speed vertical steam engine in sizes from 30 to 450 horsepower, and on leaving Cold Spring took up its development. This engine is of the inclosed self-oiling type, with two sets of reciprocating parts, the two high-pressure pistons being single-acting and the two low-pressure pistons double-acting.

JOHN B. ALLAN

John B. Allan, a prominent engineer and salesman identified with the power plant field, died on July 28 at his home in Oak Park, Ill. He was born in Davenport, Iowa, in 1860 and received his common and high-school education in that city. He completed a course in mechanical engineering at the Worcester Polytechnic Institute, graduating with the class of 1880. Mr. Allen entered the employment of Edward P. Allis & Co. in 1881 and served in various capacities until he was made manager of the Chicago office, which was the first branch office started by the company. Mr. Allan was prominently identified with the early development of the street and elevated railways of Chicago. He sold most of the power-house equipment at the time the systems were changed from the horse cars to cable cars and later to electric lines. At the organization of the Allis-Chalmers Co., he was made vice-president and general manager, which position he held until 1904. At that time he resigned and was made general Western sales manager of the Westing-

JOHN B. ALLAN

house Machine Co., with headquarters in Chicago. In 1910 failing health overtook Mr. Allan and he was compelled to give up active business. Probably no man in a similar capacity was better known to the profession.

Mr. Allan had been in failing health for some time and the immediate cause of his death was tumor on the brain. Thousands of his many friends throughout the country will mourn his untimely death. He leaves besides his widow, three children, James R., Ruth R. and Margaret B., and a sister, Mrs. John Graham of San Diego, Calif. The funeral services were held at the residence on Friday morning and the burial was at Grand Rapids.

NEW EQUIPMENT

ATLANTIC COAST STATES

The City Commission, Bordentown, N. J., contemplates installing a municipal electric-light plant at an estimated cost of $40,000.

Press reports state that the Singer Mfg. Co., Elizabeth, N. J., will build a new power station at its plant at Elizabethport.

The Town Council, Gettysburg, Penn., plans to construct a municipal electric-light plant. An engineer will be engaged to prepare plans and estimates for the plant.

SOUTHERN STATES

The Board of Aldermen, Maben, Miss., has granted a franchise to F. H. Mudd, for the establishment of an electric-light plant at Maben.

Bids will soon be received by the city of Nashville, Tenn., for a motor-driven pump. The bids recently received were rejected on account of being too high.

The Cave City Ice Co., Cave City, Ky., contemplates installing an electric-light plant in connection with its present equipment.

Bids will be received by S. D. Jones, Business Mgr., of the Board of Education, Louisville, Ky., until Aug. 19, for the installation of heating and ventilating equipment in the Flat Lick School.